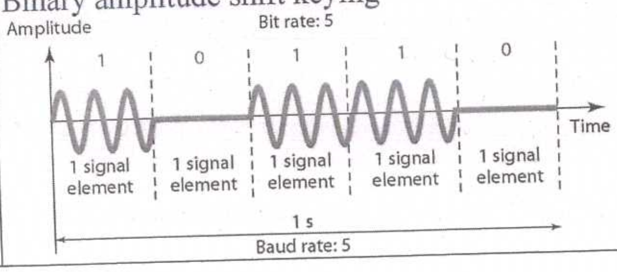
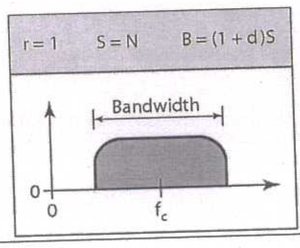
SCHEME OF VALUATION

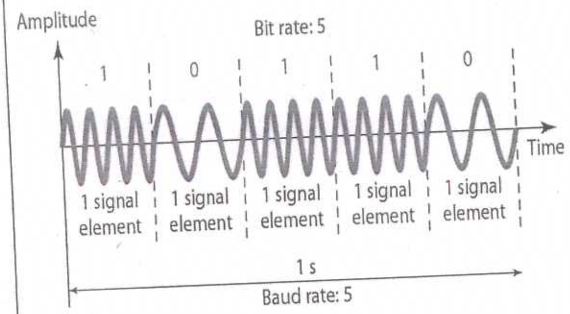
Revision 2015 Course Title : DATA COMMUNICATION			Course Code 4132	
Q.No	Scoring Indicator	Split up score	Sub Total	Total
I	**PART A**			
1	Data communication is the exchange of data between two devices via some form of transmission medium such as a wire cable.	2		
2	The bit rate is the number of bits sent in 1s, expressed in bits per second (bps).	2		
3	• Single cable failure can take down an entire network. • Cost of installation of a coaxial cable is high due to its thickness and stiffness. • Cost of maintenance is also high.	2*1		
4.	Byte stuffing is the process of adding 1 extra byte whenever there is a flag or escape character in the text.	2		
5	To detect or correct errors redundant bits or extra bits need to send with data.	2		10
II	**PART B**			
	• Text • Numbers • Images • Audio • Video	2		
	Text is represented as a bit pattern, a sequence of bits (Os or Is). Numbers are also represented by bit patterns, the number is directly converted to a binary number to simplify mathematical operations. Images are also represented by bit patterns. An image is composed of a matrix of pixels (picture elements), where each pixel is a small dot. The size of the pixel depends on the resolution. Audio refers to the recording or broadcasting of sound or music. It is continuous, not discrete. Video refers to the recording or broadcasting of a picture or movie. Video can either be produced as a continuous entity (e.g., by a TV camera), or it can be a combination of images, each a discrete entity, arranged to convey the idea of motion.	4		6

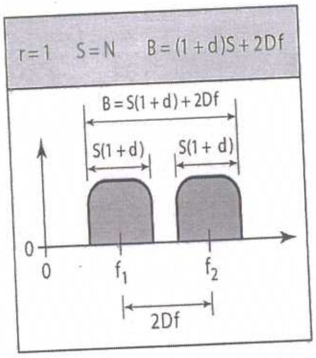
2	The most important of these are • Performance • Reliability • Security. <u>Performance</u> Performance can be measured in many ways, including transit time and response time. <u>Transit time</u> is the amount of time required for a message to travel from one device to another. <u>Response time</u> is the elapsed time between an inquiry and a response. The performance of a network depends on a number of factors, including the number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software. <u>Reliability</u> In addition to accuracy of delivery, network reliability is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe. <u>Security</u> Network security issues include protecting data from unauthorized access, protecting data from damage and development, and implementing policies and procedures for recovery from breaches and data losses.	1.5 1.5 1.5 1.5			6
3	**<u>Amplitude Shift Keying (ASK)</u>** • ASK is implemented by changing the amplitude of a carrier signal to reflect amplitude levels in the digital signal. • For example: a digital "1" could not affect the signal, whereas a digital "0" would, by making it zero. • The line encoding will determine the values of the analog waveform to reflect the digital data being carried. **<u>Bandwidth of ASK</u>** • The bandwidth B of ASK is proportional to the signal rate S. $B = (1+d)S$ • "d" is due to modulation and filtering, lies between 0 and 1. Binary amplitude shift keying 	1 1			

Frequency Shift Keying 1

- The digital data stream changes the frequency of the carrier signal, f_c.
- For example, a "1" could be represented by $f_1=f_c+\Delta f$, and a "0" could be represented by $f_2=f_c-\Delta f$.

Binary frequency shift keying 1





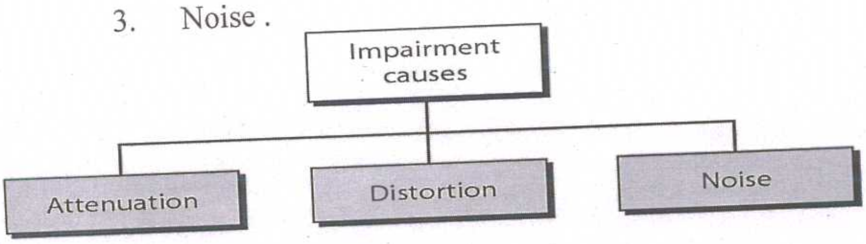
1

Bandwidth of FSK 6

- If the difference between the two frequencies (f_1 and f_2) is $2\Delta f$, then the required BW B will be: $B = (1+d)xS + 2\Delta f$. 1

4 **Transmission Impairments**

- For analog signals, these impairments introduce various random modifications that degrade the signal quality. For digital signals, bit errors are introduced: A binary 1 is transformed into a binary 0 and vice versa.
- In short, what is sent is not what is received.
- Three types of impairments usually occur :
  1. Attenuation.
  2. Distortion.
  3. Noise .



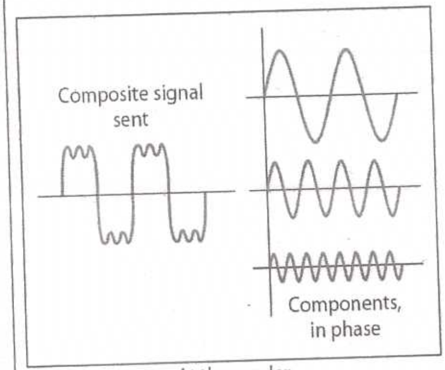
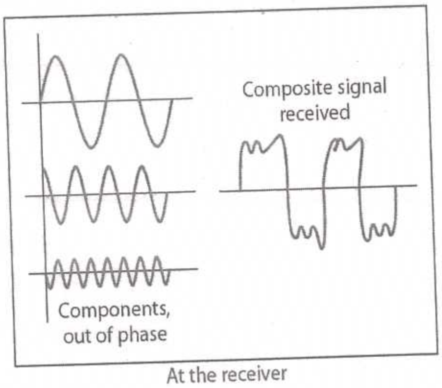
2

Attenuation

- Attenuation means loss of energy. When a signal, simple or complex travels through a medium, it loses some of its energy so that it can overcome the resistance of the medium. To compensate for this loss, amplifiers or repeaters are used to boost the signal. 1

Distortion

- It means that the signal changes its form or shape. Distortion occurs in a composite signal, made of different frequencies. Each signal component has its own propagation speed through a medium and therefore its own delay in arriving at the final destination.

	 At the sender  At the receiver	1			
	Noise • For any data transmission event, the received signal will consist of the transmitted signal, modified by the various distortions imposed by the transmission system, plus additional unwanted signals that are inserted somewhere between transmission and reception; these undesired signals are referred to as noise -a major limiting factor in communications system performance.	1			6
	There are several types of noises. 1. Thermal noise. 2. Intermodulation noise. 3. Crosstalk. 4. Impulse noise.	1			
5	**Advantages** • Greater capacity Example: Data rates at 100 Gbps • Smaller size & light weight • Lower attenuation • Electromagnetic isolation • More resistance to corrosive materials • Greater repeater spacing facility Example: After every 10s of km at least	3			6
	Disadvantages • Installation and maintenance need expertise • Only Unidirectional light propagation • Much more expensive	3			

6 Cyclic Redundancy Check

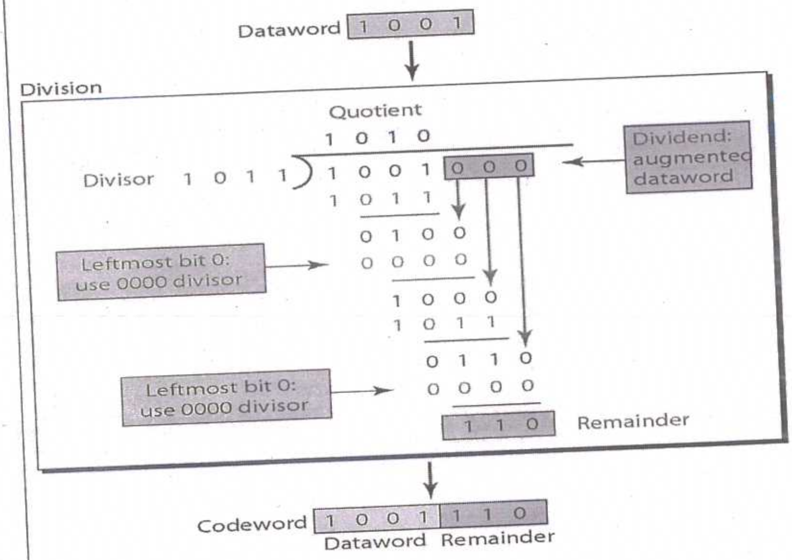
- Used in networks such as LANs and WANs.

Encoder

- The dataword has k bits(4 here); the codeword has n bits (7 here). The size of the dataword is augmented by adding n - k (3 here) Os to the right-hand side of the word. The n-bit result is fed into the generator. The generator uses a divisor of size n - k + I (4 here), predefined and agreed upon. The generator divides the augmented dataword by the divisor.

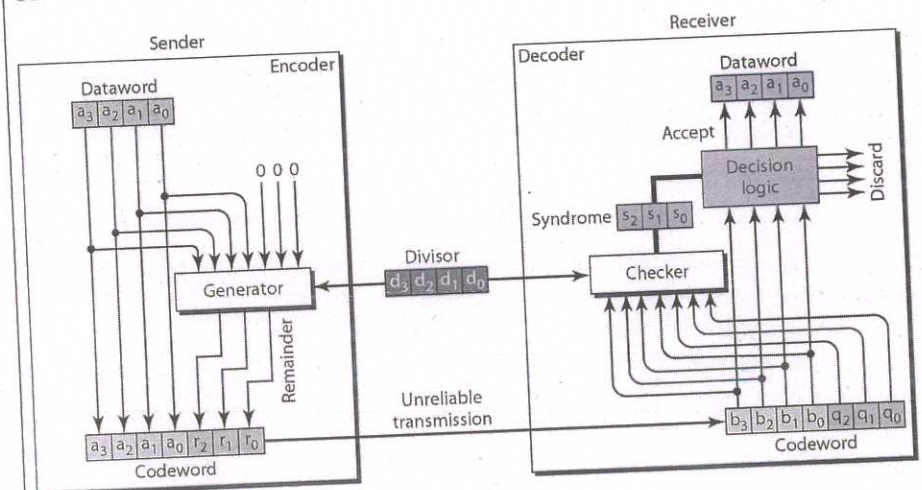
- The quotient of the division is discarded; the remainder (r2r1r0) is appended to the dataword to create the codeword. 1.5

Division in CRC encoder



1

CRC encoder and decoder

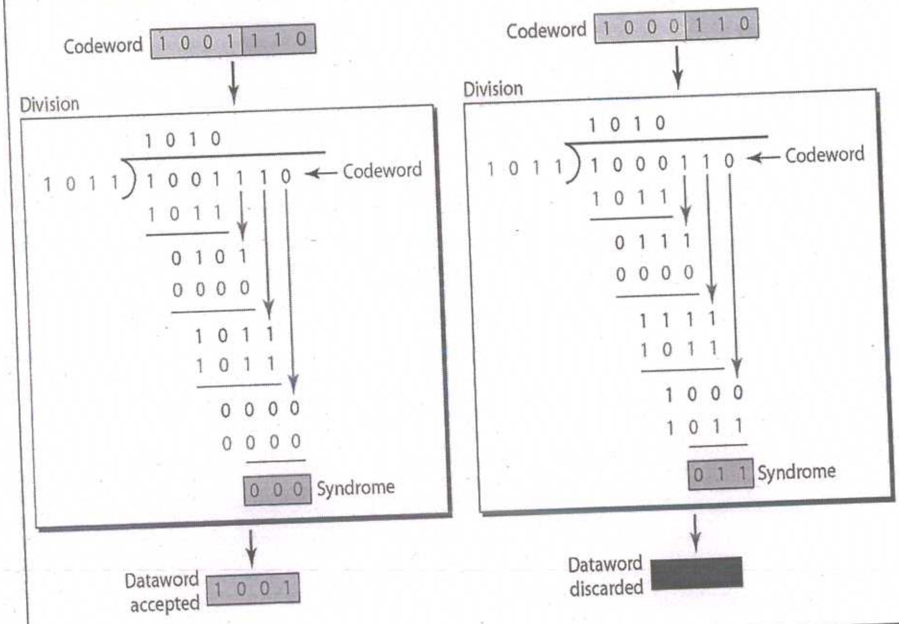


1

Decoder 1.5

- The codeword can change during transmission.
- The decoder does the same division process as the encoder.
- The remainder of the division is the syndrome.
- If the syndrome is all Os, there is no error; the dataword is separated from the received codeword and accepted. Otherwise, everything is discarded.

Division in the CRC decoder for two cases



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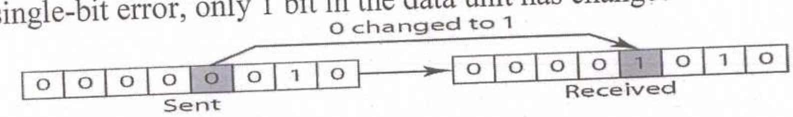
7 **Types of Errors** 2

1. Single-Bit Error
2. Burst Error

Single-Bit Error 1

In a single-bit error, only 1 bit in the data unit has changed.

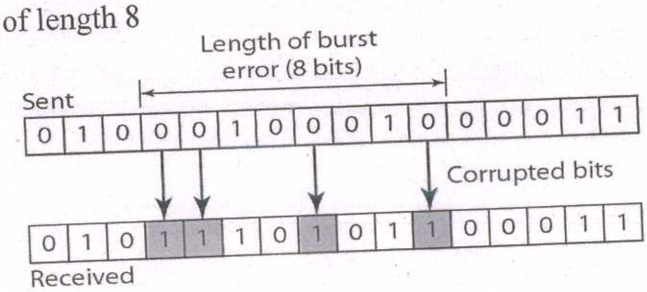


1

Burst Error

A burst error means that 2 or more bits in the data unit have changed.

Burst error of length 8 1

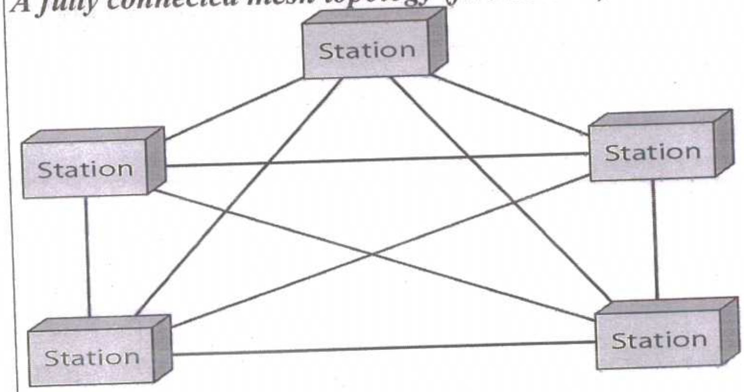


1 6

The length of the burst is measured from the first corrupted bit to the last corrupted bit. Some bits in between may not have been corrupted.

PART C

III(a) ***A fully connected mesh topology (five devices)***



2

Mesh

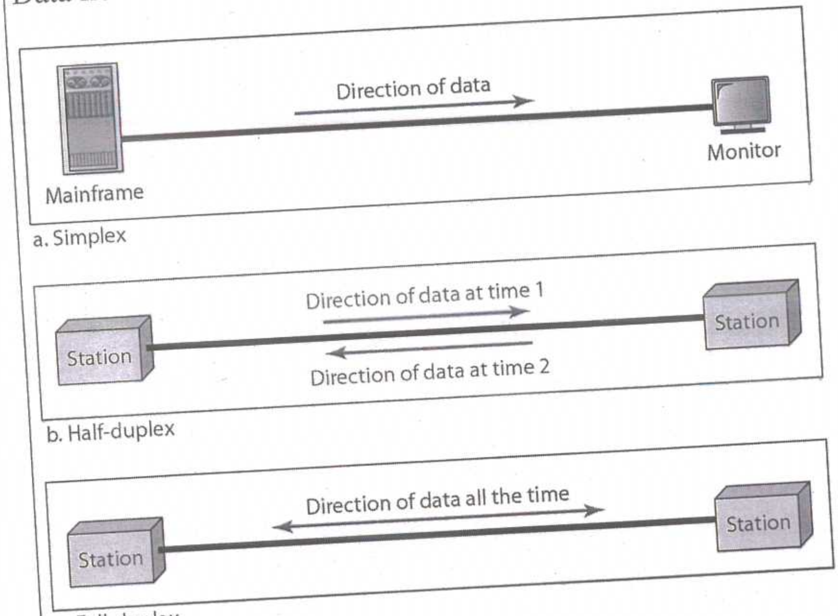
A mesh has several advantages over other network topologies.

- The use of dedicated links guarantees that each connection can carry its own data load, thus eliminating the traffic problems that can occur when links must be shared by multiple devices.
- A mesh topology is robust. If one link becomes unusable, it does not incapacitate the entire system.
- There is the advantage of privacy or security. When every message travels along a dedicated line, only the intended recipient sees it. Physical boundaries prevent other users from gaining access to messages. 2.5
- Point-to-point links make fault identification and fault isolation easy. Traffic can be routed to avoid links with suspected problems. This facility enables the network manager to discover the precise location of the fault and aids in finding its cause and solution. 7

The main disadvantages of a mesh are

- The amount of cabling and the number of I/O ports required. 2.5
- Because every device must be connected to every other device, installation and reconnection are difficult.
- Sheer bulk of the wiring can be greater than the available space (in walls, ceilings, or floors) .
- The hardware required to connect each link (I/O ports and cable) is expensive.

III(b) Communication between two devices can be made in 3 ways.
Data flow in communication



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

2

Simplex

- In simplex mode, the communication is unidirectional
- Only one of the two devices on a link can transmit; the other can only receive. 2
- Keyboards and traditional monitors are examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output.
- The simplex mode can use the entire capacity of the channel to send data in one direction.

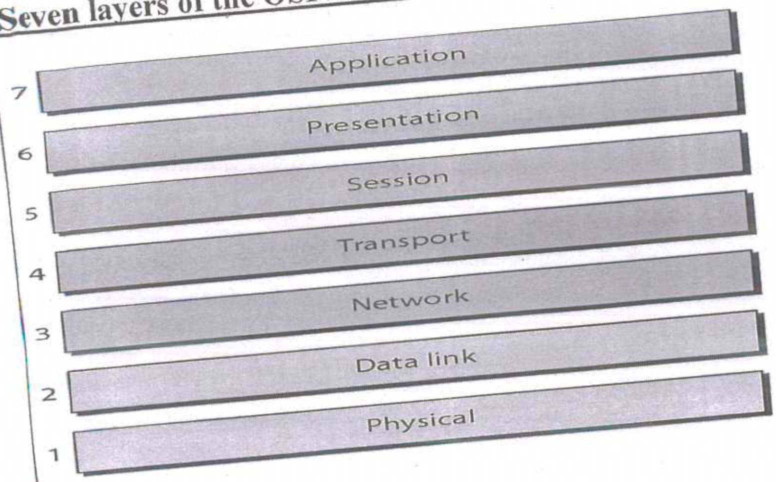
Half-Duplex

- In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa . 2
- The half-duplex mode is like a one-lane road with traffic allowed in both directions. Walkie-talkies are half-duplex systems.
- In a half-duplex transmission, the entire capacity of a channel can be utilized for each direction.

Full-Duplex

- In full-duplex mode (also called duplex), both stations can transmit and receive simultaneously.
- The full-duplex mode is like a two way street with traffic flowing in both directions at the same time. In full-duplex mode, signals going in one direction share the capacity of the link with signals going in the other direction. This sharing can occur in two ways: Either the link must contain two physically separate transmission paths, one for sending and the other for receiving. 2 8
- One common example of full-duplex communication is the telephone network.
- The capacity of the channel, however, must be divided between the two directions.

IV(a) **Seven layers of the OSI model**

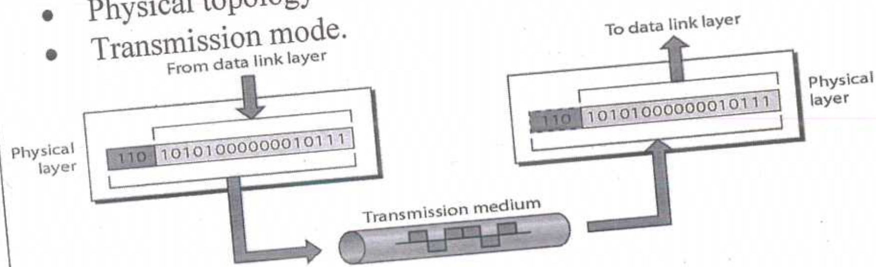


1

Physical layer

The physical layer is responsible for movements of individual bits from one hop (node) to the next.

- Physical characteristics of interfaces and medium.
- Physical layer defines the type of transmission medium
- Representation of bits
- Data rate
- Synchronization of bits
- Line configuration
- Physical topology
- Transmission mode.

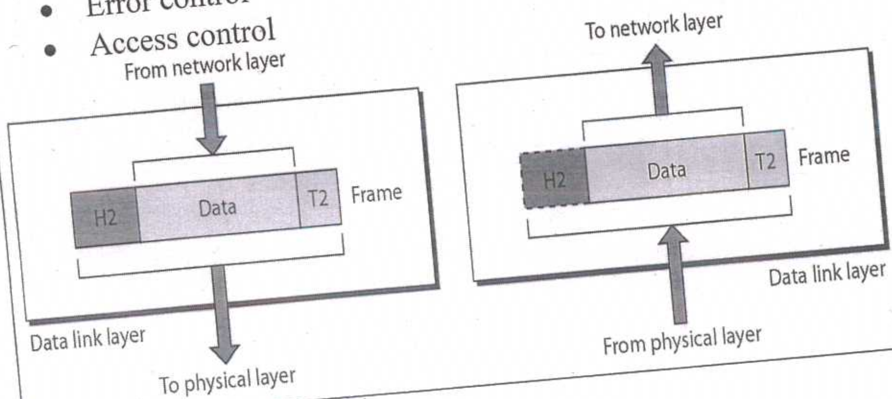


2

Data Link layer

The data link layer is responsible for moving frames from one hop (node) to the next.

- Framing
- Physical addressing
- Flow control
- Error control
- Access control

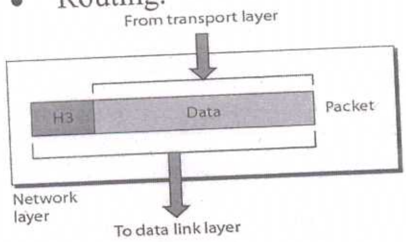


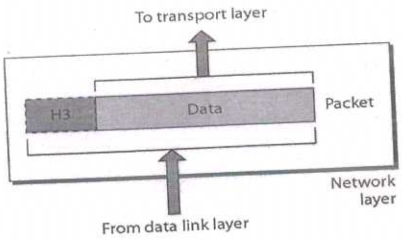
2

Network layer

The network layer is responsible for the delivery of individual packets from the source host to the destination host.

- Logical addressing
- Routing.



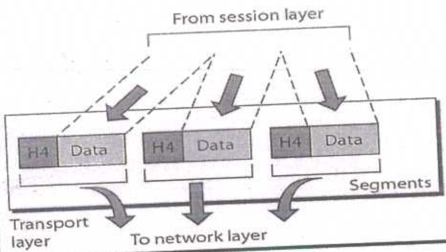


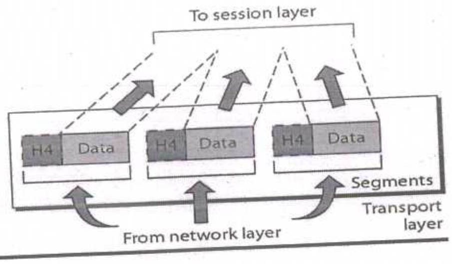
2

Transport layer

The transport layer is responsible for the deliveryof a message from one process to another.

- Error control
- Flow control
- Service-point addressing
- Connection control
- Segmentation and reassembly



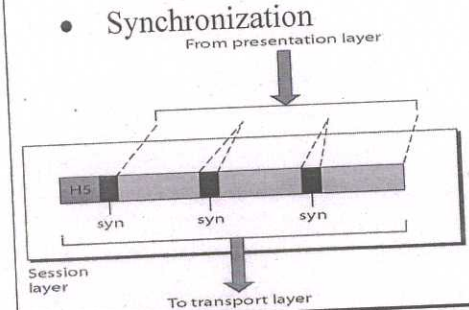


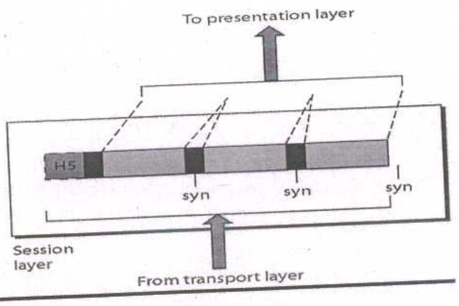
2

Session layer

The session layer responsible for dialog control and synchronization.

- It establishes, maintains, and synchronizes the interaction among communicating systems
- Dialog control
- Synchronization



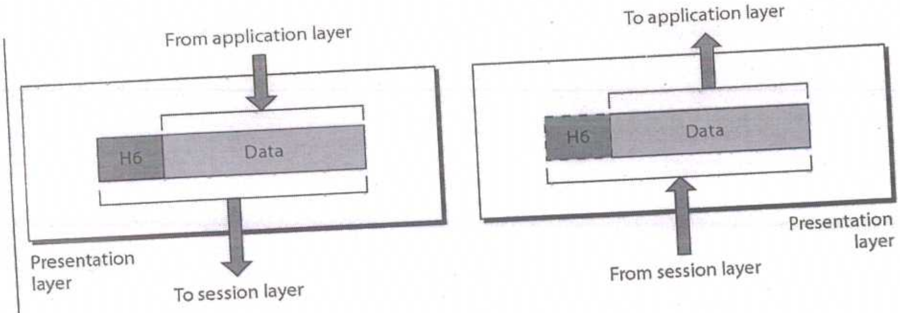


2

Presentation layer

The presentation layer is responsible for translation, compression, and encryption.

- Translation
- Encryption
- Compression.



2

Application layer

The application layer responsible for providing services to the user.

- Network virtual terminal
- File transfer, access, and management
- Mail services
- Directory services

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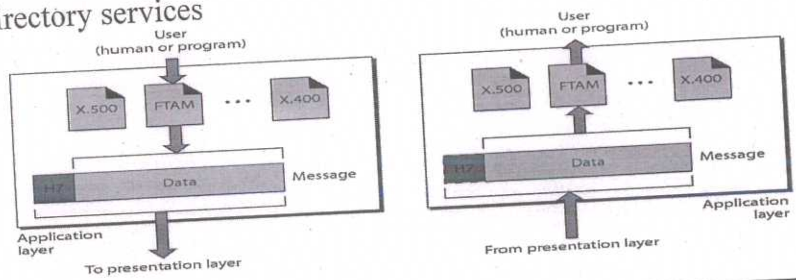


2

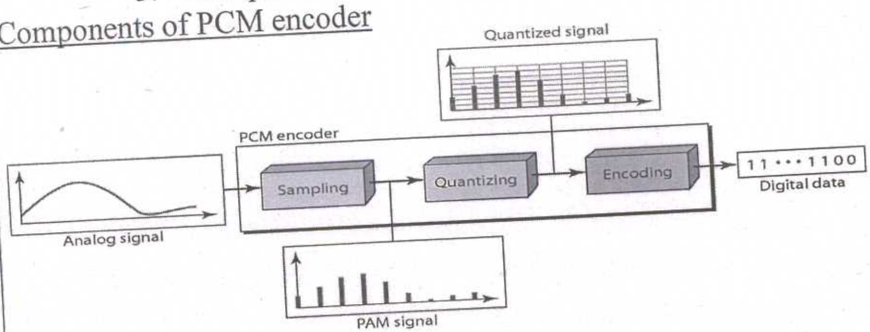
V(a) Pulse Code Modulation (PCM)

A PCM encoder has three processes consists of three steps to digitize an analog signal:

1. The analog signal is sampled.
2. The sampled signal is Quantized.
3. The quantized values are encoded as stream of bits.

1

Components of PCM encoder



1

Sampling

- Analog signal is sampled every T_S secs.
- T_s is referred to as the sampling interval.
- $f_s = 1/T_s$ is called the sampling rate or sampling frequency.

The term sampling means measuring the amplitude of the signal at equal intervals.

The sampling process is sometimes referred to as Pulse Amplitude Modulation(PAM).

2

Quantization

- Sampling results in a series of pulses of varying amplitude values ranging between two limits: a min and a max.
- The amplitude values are infinite between the two limits.
- We need to map the infinite amplitude values onto a finite set of known values.
- This is achieved by dividing the distance between min and max into L zones, each of height Δ.

$\Delta = (max - min)/L$

Quantization Levels

- The midpoint of each zone is assigned a value from 0 to L-1 (resulting in L values)
- Each sample falling in a zone is then approximated to the value of the midpoint.

Quantization Zones

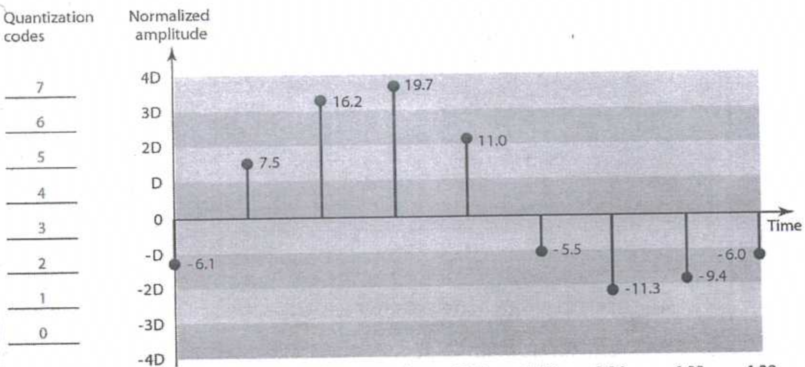
- Assume we have a voltage signal with amplitutes V_{min}=-20V and V_{max}=+20V. 2
- We want to use L=8 quantization levels.
- Zone width $\Delta = (20 - -20)/8 = 5$
- The 8 zones are: -20 to -15, -15 to -10, -10 to -5, -5 to 0, 0 to +5, +5 to +10, +10 to +15, +15 to +20
- The midpoints are: -17.5, -12.5, -7.5, -2.5, 2.5, 7.5, 12.5, 17.5

Assigning Codes to Zones

- Each zone is then assigned a binary code.
- The number of bits required to encode the zones, or the number of bits per sample as it is commonly referred to, is obtained as follows:

$n_b = \log_2 L$

Quantization and encoding of a sampled signal



Normalized PAM values	-1.22	1.50	3.24	3.94	2.20	-1.10	-2.26	-1.88	-1.20
Normalized quantized values	-1.50	1.50	3.50	3.50	2.50	-1.50	-2.50	-1.50	-1.50
Normalized error	-0.38	0	+0.26	-0.44	+0.30	-0.40	-0.24	+0.38	-0.30
Quantization code	2	5	7	7	6	2	1	2	2
Encoded words	010	101	111	111	110	010	001	010	010

Encoding

Bit rate and bandwidth requirements of PCM

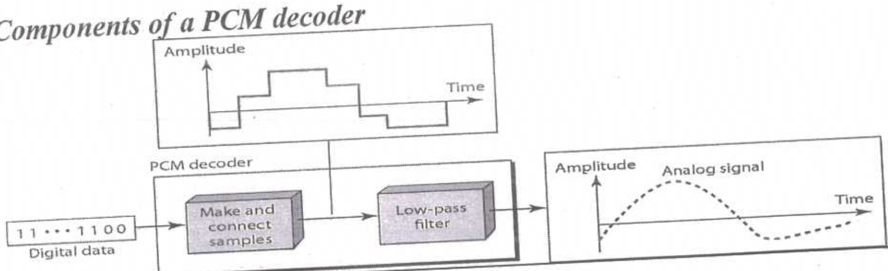
- The last step in PCM is encoding.
- After each sample is quantized and the number of bits per sample is decided, each sample can be changed to an nb - bit code word.
- The bit rate of a PCM signal can be calculated form the number of bits per sample x the sampling rate 2

  Bit rate = n_b x f_s
- The bandwidth required to transmit this signal depends on the type of line encoding used.
- A digitized signal will always need more bandwidth than the original analog signal.

PCM Decoder

- To recover an analog signal from a digitized signal we follow the following steps:
  - We use a hold circuit that holds the amplitude value of a pulse till the next pulse arrives. 2
  - We pass this signal through a low pass filter with a cutoff frequency that is equal to the highest frequency in the pre-sampled signal. 10
- The higher the value of L, the less distorted a signal is recovered.

Components of a PCM decoder



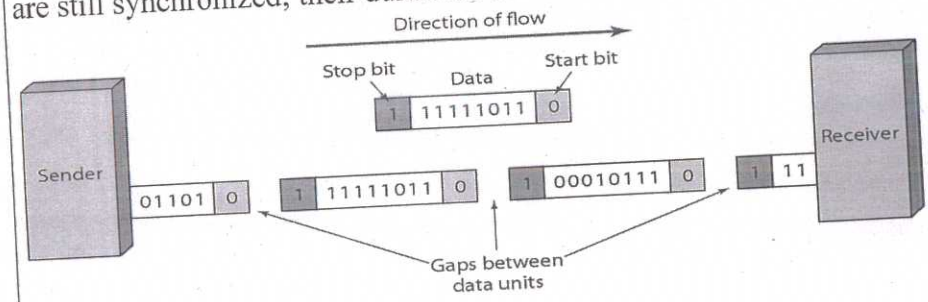
V(b) Serial transmission methods

- Asynchronous Transmission
- Synchronous Transmission
- Isochronous 1

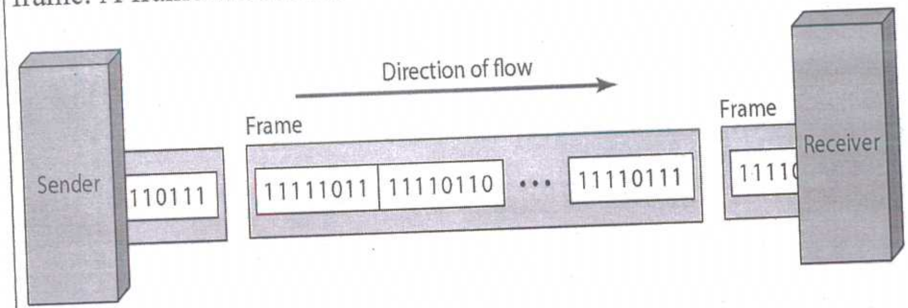
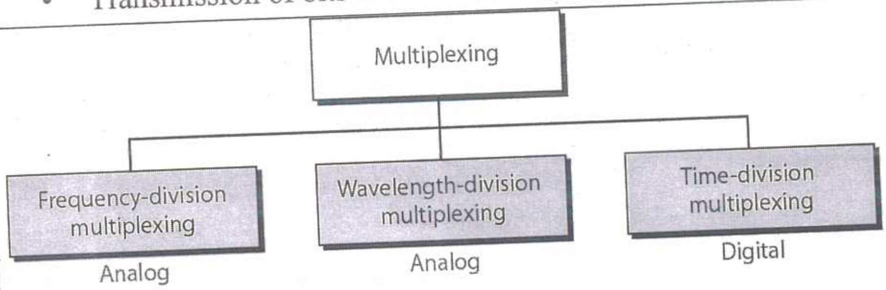
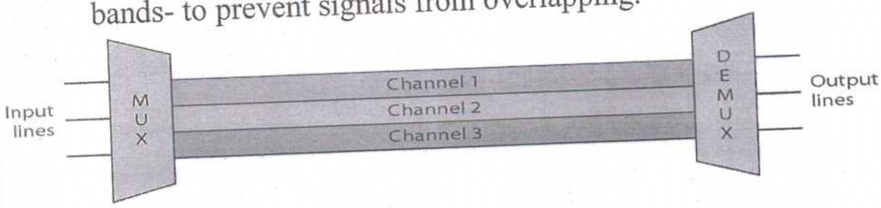
Asynchronous Transmission

In asynchronous transmission, we send 1 start bit (0) at the beginning and 1 or more stop bits (1s) at the end of each byte. There may be a gap between each byte.

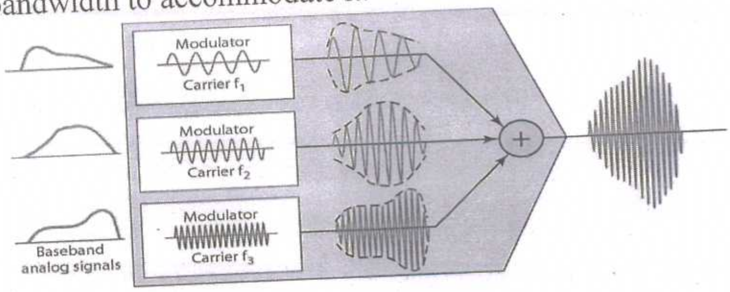
Asynchronous here means "asynchronous at the byte level,"but the bits are still synchronized; their durations are the same.



1.5

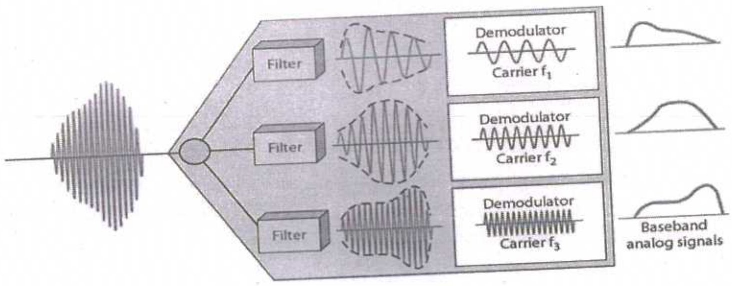
	Connection of a terminal to a computer is a natural application for asynchronous transmission <u>Synchronous Transmission</u> In synchronous transmission, we send bits one after another without start or stop bits or gaps. It is the responsibility of the receiver to group the bits. The bits are usually sent as bytes and many bytes are grouped in a frame. A frame is identified with a start and an end byte.  It is more useful for high speed applications like transmission of data from one computer to another.	1.5			
	<u>Isochronous</u> • In isochronous transmission we cannot have uneven gaps between frames. • Transmission of bits is fixed with equal gaps.	1		5	
VI(a)		1			
	Frequency-division multiplexing (FDM) • In FDM, signals generated by each sending device modulate different carrier frequencies. These modulated signals are then combined into a single composite signal that can be transported by the link. • Carrier frequencies are separated by enough bandwidth to accommodate the modulated signal. • Channels must be separated by strips of unused bandwidth -guard bands- to prevent signals from overlapping.  **<u>Multiplexing Process</u>** • Each source generates a signal of a similar frequency range.	1			

- Inside the multiplexer, these similar signals are modulated onto different carrier frequencies (f1,f2, andf3). 1
- The resulting modulated signals are then combined into a single composite signal that is sent out over a media link that has enough bandwidth to accommodate it.



Demultiplexing Process

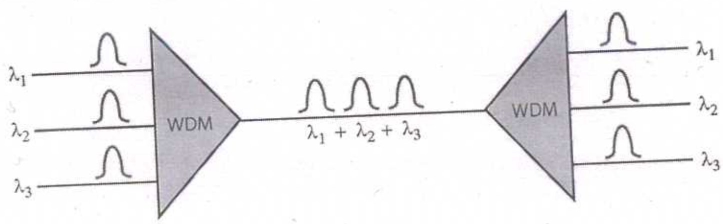
- The demultiplexer uses a series of filters to decompose the multiplexed signal into its constituent component signal.
- The individual signals are then passed to a demodulator that separates them form their carriers and pass them to the output lines.

 2

Wave Division Multiplexing (WDM)

- It is conceptually the same as FDM, except that the multiplexing and demultiplexing involve optical signals (light signals) transmitted through fiber optic channels.
- Very narrow bands of light from different sources are combined to make a wider band of light. 2

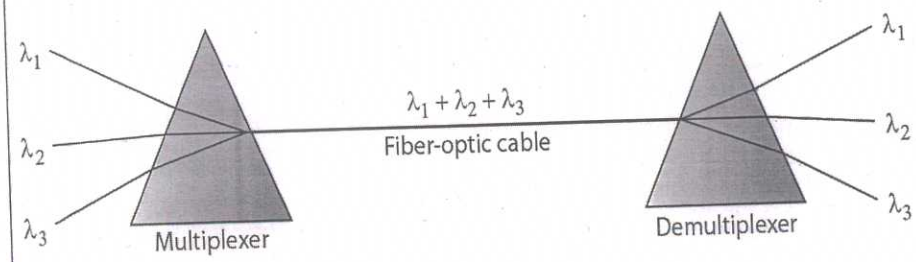
At the receiver, the signals are separated by the demultiplexer.



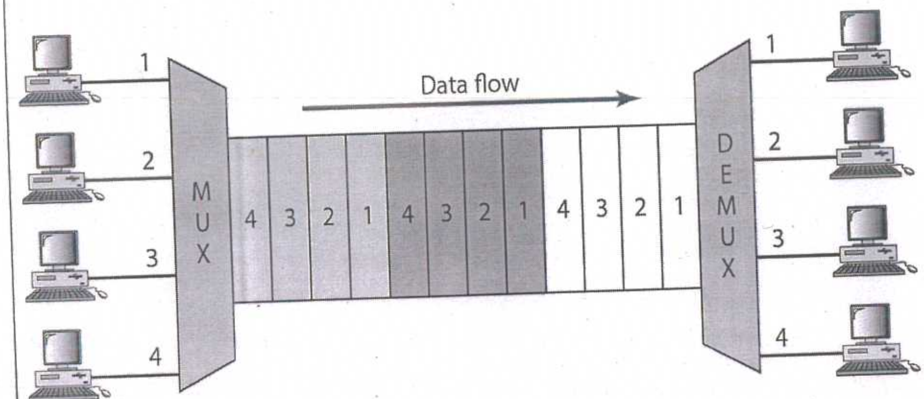
WDM is an analog multiplexing technique to combine optical signals.

- In WDM combine multiple light sources into one single light at the multiplexer and do the reverse at the demultiplexer.
- Combining and splitting of light sources are easily handled by a prism.
- A multiplexer is made to combine several input beams of light, each containing a narrow beam of frequencies, into one output beam of a wider band of frequencies.
- A demultiplxer can be made to reverse the process.

2



- **Time Division Multiplexing**
- TDM is a digital process that allows several connections to share the high bandwidth of a link. Each connection occupies a portion of time in the link.
- TDM is a digital multiplexing technique for combining several low-rate digital channels into high-rate one.



2

- SYNCHRONOUS TDM
- STATISTICAL TDM

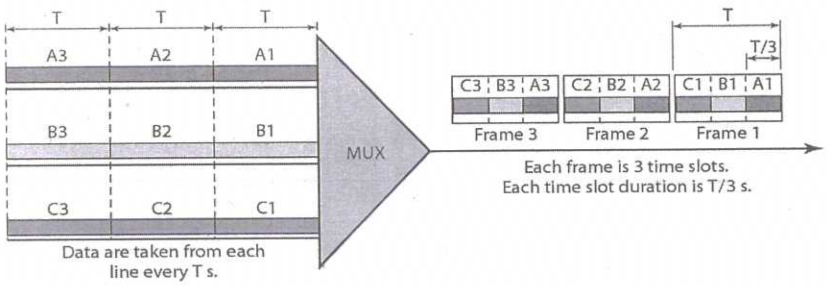
Synchronous time-division multiplexing

Time slots and frames

- In synchronous TDM, the data flow of each input connection is divided into units, where each input occupies one input timeslot.

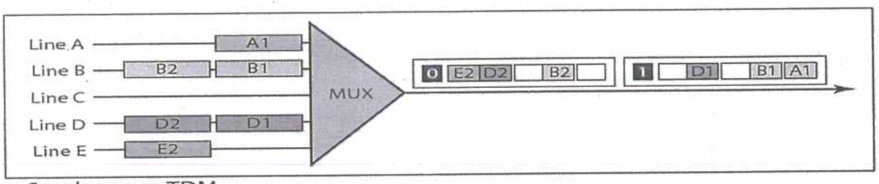
A unit can be 1 bit ,one character, or one block of data.

- In synchronous TDM,a round of data units from each input connection is collected into a frame. 2
- If there are n connections, a frame is divided into n timeslot and one slot is allocated for each unit.
- In synchronous TDM, the data rate of the link is n times faster, and the unit duration is n times shorter.
- Time slots are grouped into frames. In a system with n input lines, each frame has n slots, with each slot allocated to carrying data from a specific input line.

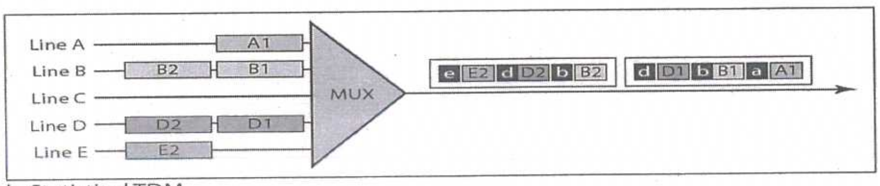


Statistical Time-Division Multiplexing

- An output slot in synchronous TDM is totally occupied by data ;in statistical TDM ,a slot needs to carry data as well as the address of the destination. 1 15
- The frames in statistical TDM need not be synchronized, so we do not need synchronization bits.
- The capacity of the link is normally less than the sum of the capacities of each channel.



a. Synchronous TDM 1



b. Statistical TDM

VII(a) **Propagation methods**

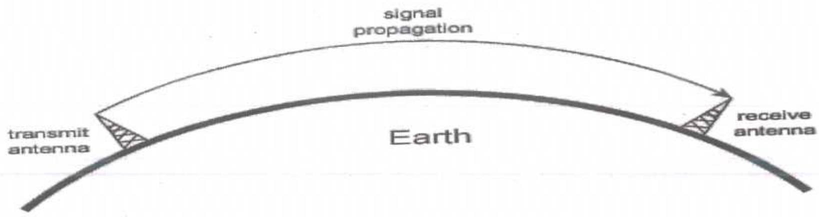
Unguided signals travels from the source to destination inseveral ways it is known as propagation.

They are three types:

- Ground propagation
- Sky propagation
- Line-of-Sight Propagation.

Ground propagation: 2

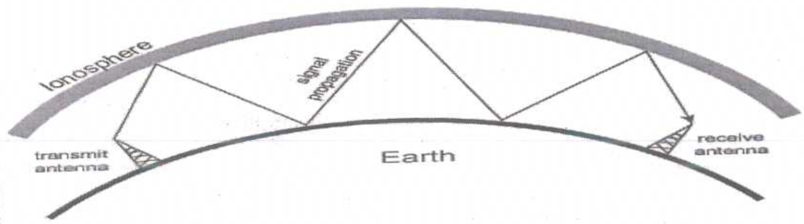
- Radio waves travel through the lowest portion of the atmosphere
- Touching the earth.



(a) Ground-wave propagation (below 2 MHz)

Sky propagation: 2

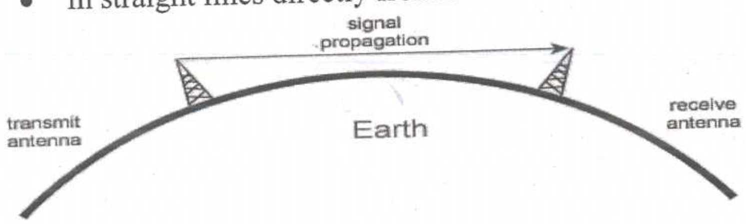
- Radio waves radiate to the ionosphere then they are reflected back to earth.



(b) Sky-wave propagation (2 to 30 MHz)

Line-of-Sight Propagation: 6

- In straight lines directly from antenna to antenna.

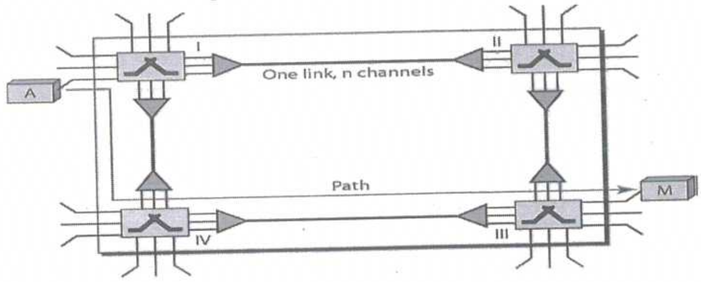


2

(c) Line-of-sight (LOS) propagation (above 30 MHz)

VII(b) **CIRCUIT-SWITCHING**

A circuit-switched network consists of a set of switches connected by physical links. A connection between two stations is a dedicated path made of one or more links. However, each connection uses only one dedicated channel on each link. Each link is normally dividedinto n channels by using FDM or TDM.



In circuit switching, the resources needto be reserved during the setup phase;the resources remain dedicated for theentire duration of data transfer until theteardown phase. 3

There is no addressing involved during data transfer.

Three Phases

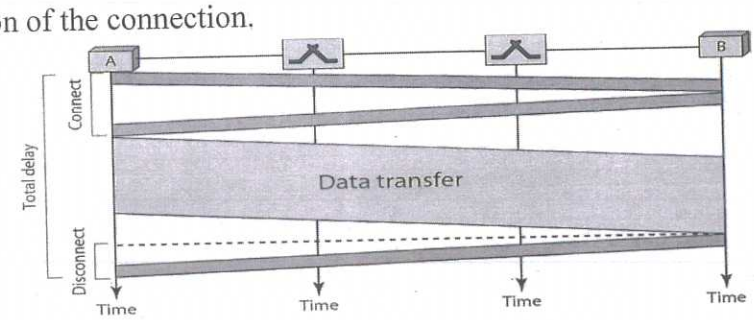
1.Setup Phase
Before the two parties (or multiple parties in a conference call) can communicate, a dedicated circuit (combination of channels in links) needs to be established.

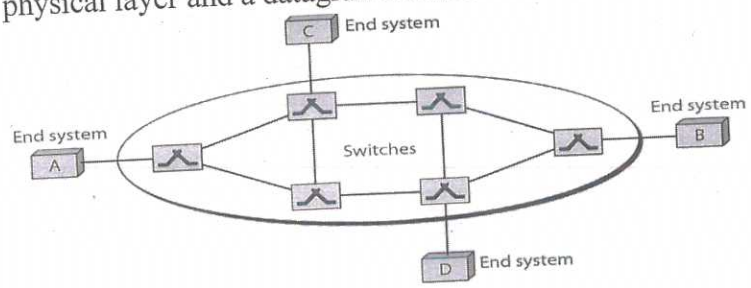
2.Data Transfer Phase
After the establishment of the dedicated circuit (channels), the two parties 3
can transfer data.

3.Teardown Phase
When one of the parties needs to disconnect, a signal is sent to each switch to release the resources.

Efficiency
It can be argued that circuit-switched networks are not as efficient as the 1.5
other two types of networks because resources are allocated during the entire duration of the connection. These resources are unavailable to other
connections. In a telephone network, people normally terminate the 9
communication when they have finished their conversation. 1.5

Delay
The delay in this type of network is minimal. During data transfer the data are not delayed at each switch; the resources are allocated for the duration of the connection.



VIII(a)	**Microwaves** Microwaves are ideal when large areas need to be coveredand there are no obstacles in the path. • Microwaves are unidirectional • Micro waves electromagnetic waves having frequency between 1 GHZ and 300 GHZ. • There are two types of micro waves data communication system : terrestrial and satellite • Micro waves are widely used for one to one communication between sender and receiver, example: cellular phone, satellite networks and in wireless LANs(wifi), WiMAX,GPS.	3			
	Radio Waves • Omnidirectional Antenna • Frequencies between 3 KHz and 1 GHz. • Used for multicasts(multiple way) communications, such as radio and television, and paging system. • Radio waves can penetrate buildings easily, so that widely use for indoors & outdoors communication.	3		6	
VIII(b)	**VIRTUAL-CIRCUIT NETWORKS** A virtual-circuit network is a cross between a circuitswitchednetwork and a datagram network. It has some characteristics of both. Characteristics of **virtual-circuit network** • As in a circuit-switched network, there are setup and teardown phases in addition to the data transfer phase. • Resources can be allocated during the setup phase, as in a circuit-switched network, or on demand, as in a datagram network. • As in a datagram network, data are packetized and each packet carries an address in the header. • As in a circuit-switched network, all packets follow the same path established during the connection. • A virtual-circuit network is normally implemented in the data link layer, while a circuit-switched network is implemented in the physical layer and a datagram network in the network layer.  		2		

Addressing

In a virtual-circuit network, two types of addressing are involved: global and local (virtual-circuit identifier)

Global Addressing

A source or a destination needs to have a global address-an address that can be unique in the scope of the network or internationally if the network is part of an international network.

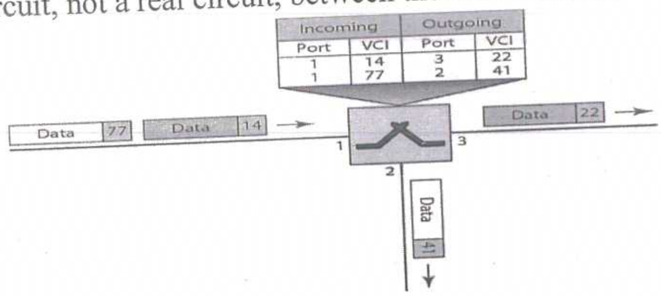
Virtual-Circuit Identifier

The identifier that is actually used for data transfer is called the virtual-circuit identifier (VCI). A VCL, unlike a global address, is a small number that has only switch scope; it is used by a frame between two switches. 2

<u>**Three Phases**</u>

- **Data Transfer Phase**

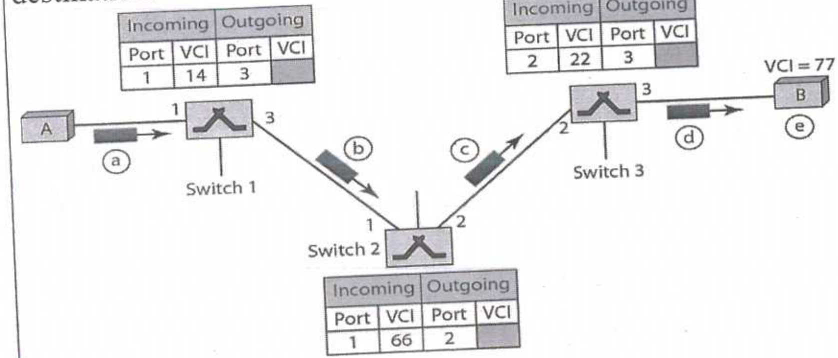
To transfer a frame from a source to its destination, all switches need to have a table entry for this virtual circuit.The data transfer phase is active until the source sends all its frames to the destination. The process creates a virtual circuit, not a real circuit, between the source and destination.



- **Setup Phase**

In the setup phase, a switch creates an entry for a virtual circuit. For example, suppose source A needs to create a virtual circuit to B. Two steps are required: the setup request and the acknowledgment.

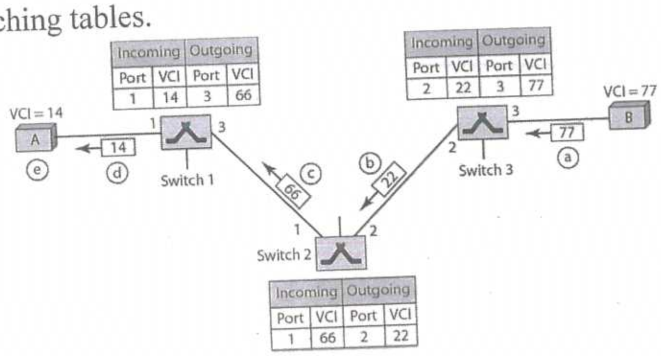
<u>**Setup Request**</u> :-A setup request frame is sent from the source to the destination.



1

<u>**Acknowledgment**</u> 1

A special frame, called the acknowledgment frame, completes the entries in the switching tables.



1

- **Teardown Phase**

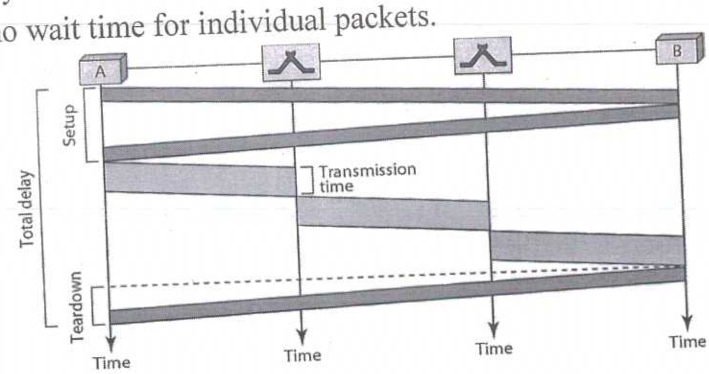
In this phase, source A, after sending all frames to B, sends a special frame called a teardown request. Destination B responds with a teardown confirmation frame. All switches delete the corresponding entry from their tables. 1

Efficiency

- Resource reservation in a virtual-circuit network can be made during the setup or can be on demand during the data transfer phase.
- There is one big advantage in a virtual-circuit network even if resource allocation is on demand. The source can check the availability of the resources, without actually reserving it.

Delay in Virtual-Circuit Networks

In a virtual-circuit network, there is a one-time delay for setup and a one-time delay for teardown. If resources are allocated during the setup phase, there is no wait time for individual packets. 1



In virtual-circuit switching, all packets belonging to the same source and destination travel the same path; but the packets may arrive at the destination with different delays if resource allocation is on demand. 9

IX(a)

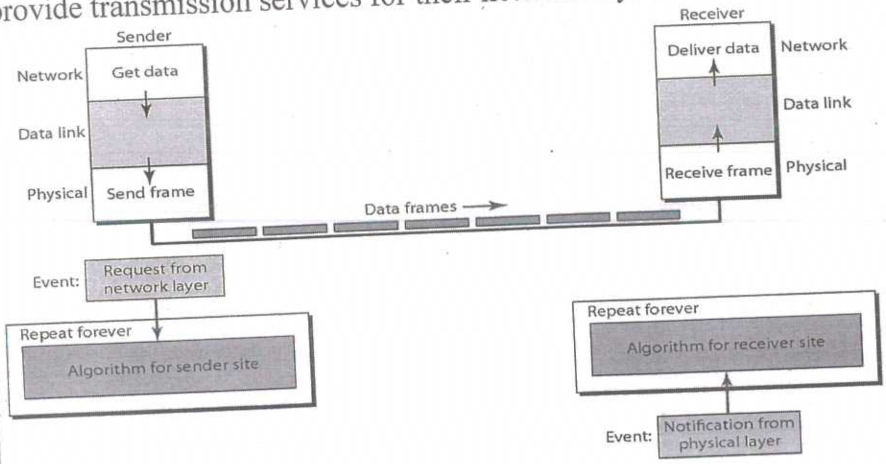
- **Simplest Protocol**
- **Stop-and-Wait Protocol**

Simplest Protocol

- It is a unidirectional protocol in which data frames are traveling in only one direction-from the sender to receiver.
- The data link layer of the receiver immediately removes the header from the frame and hands the data packet to its network layer, which can also accept the packet immediately. 2

Design

There is no need for flow control in this scheme. The data link layer at the sender site gets data from its network layer, makes a frame out of the data, and sends it. The data link layer at the receiver site receives a frame from its physical layer, extracts data from the frame, and delivers the data to its network layer. The data link layers of the sender and receiver provide transmission services for their network layers.



2

Sender-site algorithm for the simplest protocol

```
while(true)                         // Repeat forever
{
  WaitForEvent();                   // Sleep until an event occurs
  if(Event(RequestToSend))          //There is a packet to send
  {
     GetData();
     MakeFrame();
     SendFrame();                   //Send the frame
  }
}
```

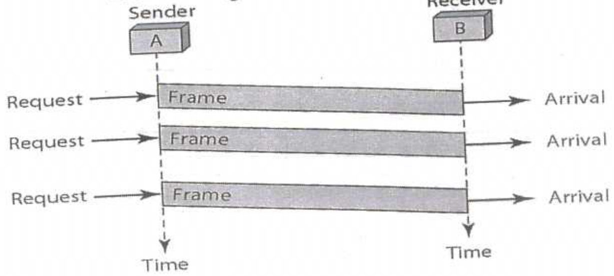
1

Receiver-site algorithm for the simplest protocol

```
while(true)                          // Repeat forever
{
  WaitForEvent();                    // Sleep until an event occurs
  if(Event(ArrivalNotification))     //Data frame arrived
  {
     ReceiveFrame();
     ExtractData();
     DeliverData();                  //Deliver data to network layer
  }
}
```

1

Flow diagram Flow diagram



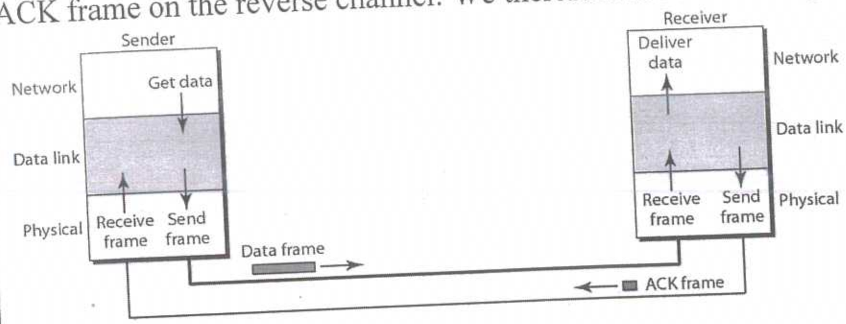
1.5

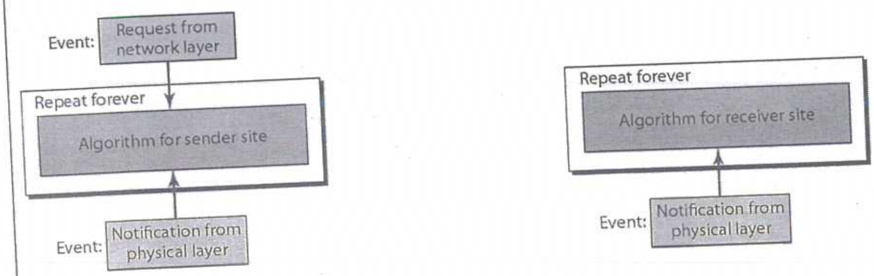
Stop-and-Wait Protocol

The sender sends one frame, stops until it receives confirmation from the receiver (okay to go ahead), and then sends the next frame. We still have unidirectional communication for data frames, but auxiliary ACK frames (simple tokens of acknowledgment) travel from the other direction. 2

Design

At any time, there is either one data frame on the forward channel or one ACK frame on the reverse channel. We therefore need a half-duplex link.





2

Sender-site algorithm for Stop-and-Wait Protocol

```
while(true)                                    //Repeat forever
canSend = true                                 //Allow the first frame to go
{
 WaitForEvent();                               // Sleep until an event occurs
 if(Event(RequestToSend) AND canSend)
 {
    GetData();
    MakeFrame();
    SendFrame();                               //Send the data frame
    canSend = false;                           //Cannot send until ACK arrives
 }
 WaitForEvent();                               // Sleep until an event occurs
 if(Event(ArrivalNotification)                 // An ACK has arrived
 {
    ReceiveFrame();                            //Receive the ACK frame
    canSend = true;
 }
}
```

1

Receiver-site algorithm for Stop-and-Wait Protocol

```
while(true)                          //Repeat forever
{
  WaitForEvent();                    // Sleep until an event occurs
  if(Event(ArrivalNotification))     //Data frame arrives
  {
     ReceiveFrame();
     ExtractData();
     Deliver(data);                  //Deliver data to network layer
     SendFrame();                    //Send an ACK frame
  }
}
```

1

Analysis

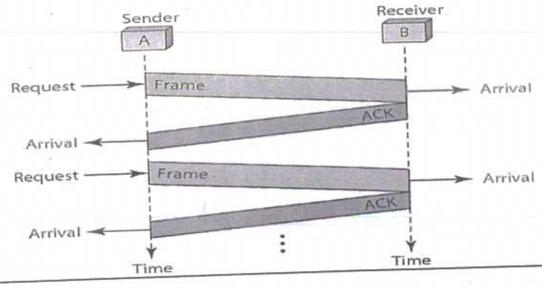
Here two events can occur:

1. A request from the network layer.
2. An arrival notification from the physical layer.

After a frame is sent, the algorithm must ignore another network layer request until that frame is acknowledged. We need somehow to prevent the immediate sending of the data frame. 15

we have used a simple canSend variable that can either be true or false. When a frame is sent, the variable is set to false to indicate that a new network request cannot be sent until canSend is true. When an ACK is received, canSend is set to true to allow the sending of the next frame.

Flow diagram 1.5

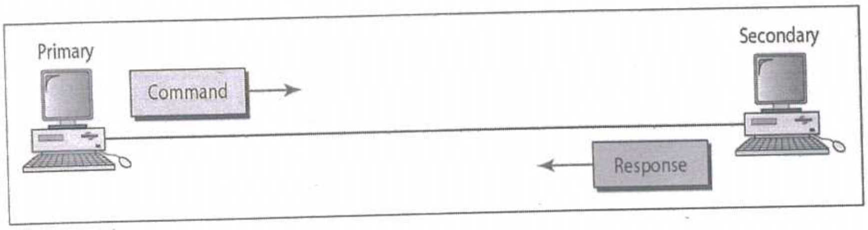


X(a) HDLC provides two common transfer modes that can be used in different configurations:

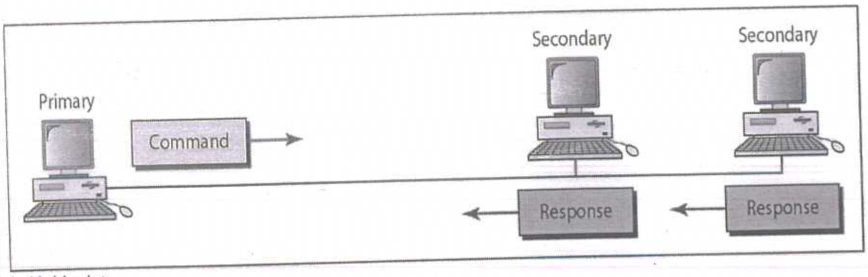
1. Normal response mode (NRM).
2. Asynchronous balanced mode (ABM).

<u>Normal Response Mode</u>

In normal response mode (NRM), the station configuration is unbalanced. one primary station and multiple secondary stations. A primary station can send commands; a secondary station can only respond. The NRM is used for both point-to-point and multiple-point links. 1



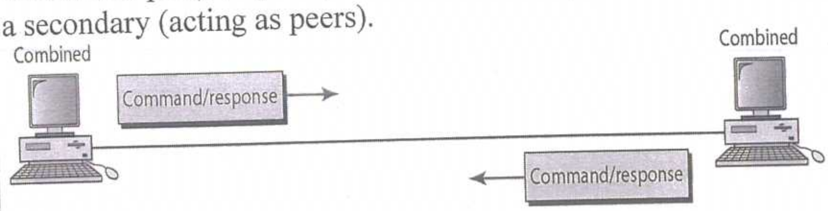
a. Point-to-point 1



b. Multipoint 1

Asynchronous Balanced Mode 1

In asynchronous balanced mode (ABM), the configuration is balanced. The link is point-to-point, and each station can function as a primary and a secondary (acting as peers).



1

Frames

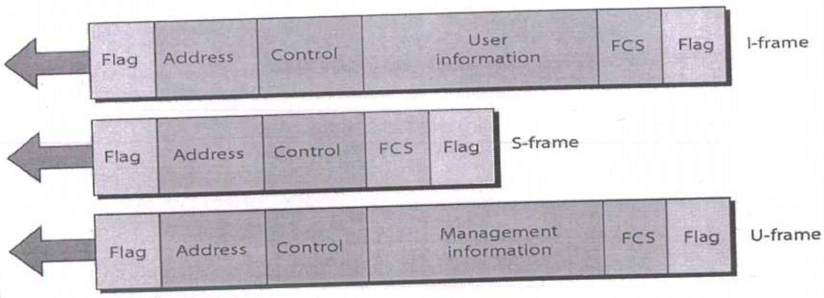
HDLC defines three types of frames: 2

1. Information frames (I-frames)
2. Supervisory frames (S-frames)
3. Unnumbered frames (V-frames).

I-frames used to transport user data and control information relating to user data (piggybacking). 8

S-frames used only to transport control information.

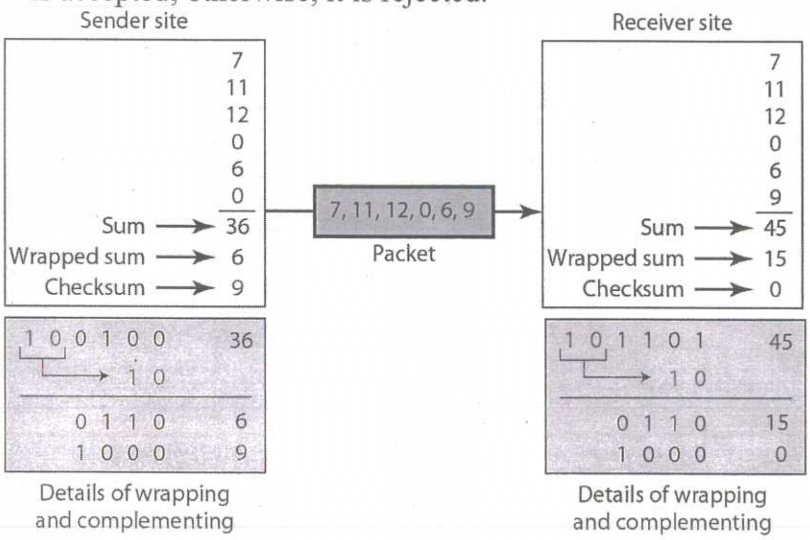
V-frames are reserved for system management. Information carried by V-frames is intended for managing the link itself. 1



X(b) The checksum detects all errors involving an odd number of bits. It also detects most errors involving even number of bits.

Sender site:

1. The message is divided into 16-bit words.
2. The value of the checksum word is set to 0.

	3. All words including the checksum are added using one's complement addition. 4. The sum is complemented and becomes the checksum. 5. The checksum is sent with the data.	2.5		
	Receiver site: 1. The message (including checksum) is divided into 16-bit words. 2. All words are added using one's complement addition. 3. The sum is complemented and becomes the new checksum. 4. If the value of checksum is 0, the message is accepted; otherwise, it is rejected.	2.5		
		2		7