Internal Assessment Test-II Computer Networks Answer Key

Que-1. Explain following ideas with respect to network Architecture: Encapsulation, multiplexing and demultiplexing.

Encapsulation

Another aspect of data communication in the OSI model: encapsulation. A packet (header and data) at level 7 is encapsulated in a packet at level 6. The whole packet at level 6 is encapsulated in a packet at level 5, and so on. In other words, the data portion of a packet at level *N* - 1 carries the whole packet (data and header and maybe trailer) from level *N.* The concept is called *encapsulation;* level *N* - 1 is not aware of which part of the encapsulated packet is data and which part is the header or trailer. For level *N* - 1, the whole packet coming from level *N* is treated as one integral unit.

Multiplexing

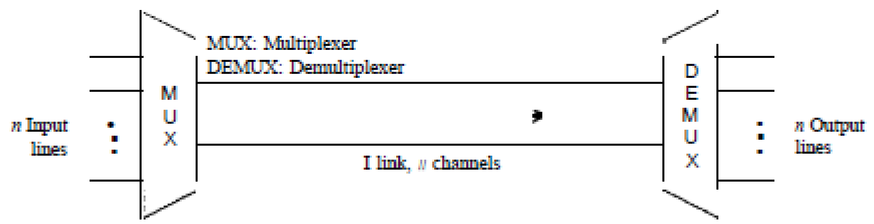
In real life, we have links with limited bandwidths. The wise use of these bandwidths has been, and will be, one of the main challenges of electronic communications. However, the meaning of *wise* may depend on the application. Sometimes we need to combine several low-bandwidth channels to make use of one channel with a larger bandwidth. Sometimes we need to expand the bandwidth of a channel to achieve goals such as privacy and antijamming. In this chapter, we explore these two broad categories of bandwidth utilization: multiplexing and spreading. In multiplexing, our goal is efficiency; we combine several channels into one. In spreading, our goals are privacy and antijamming; we expand the bandwidth of a channel to insert redundancy, which is necessary to achieve these goals.

Bandwidth utilization is the wise use of available bandwidth to achieve specific goals. Efficiency can be achieved by multiplexing; privacy and antijamming can be achieved by spreading.

Whenever the bandwidth of a medium linking two devices is greater than the bandwidth needs of the devices, the link can be shared. Multiplexing is the set of techniques that allows the simultaneous transmission of multiple signals across a single data link. As data and telecommunications use increases, so does traffic. We can accommodate this increase by continuing to add individual links each time a new channel is needed; or we can install higher-bandwidth links and use each to carry multiple signals. Today's technology includes high-bandwidth media such as optical fibre and terrestrial and satellite microwaves. Each has a bandwidth far in excess of that needed for the average transmission signal. If the bandwidth of a link is greater than the bandwidth needs of the devices connected to it, the bandwidth is wasted. An efficient system maximizes the utilization of all resources; bandwidth is one of the most precious resources we have in data communications.

In a multiplexed system, *n* lines share the bandwidth of one link. Figure 6.1 shows the basic format of a multiplexed system. The lines on the left direct their transmission streams to a multiplexer (MUX), which combines them into a single stream (many-to-one). At the receiving end, that stream is fed into a demultiplexer (DEMUX), which separates the stream back into its component transmissions (one-to-many) and directs them to their corresponding lines. In the figure, the word link refers to the physical path. The word channel refers to the portion of a link that carries a transmission between a given pair of lines. One link can have many *(n)* channels.

Figure 6.1 *Dividing a link into channels*

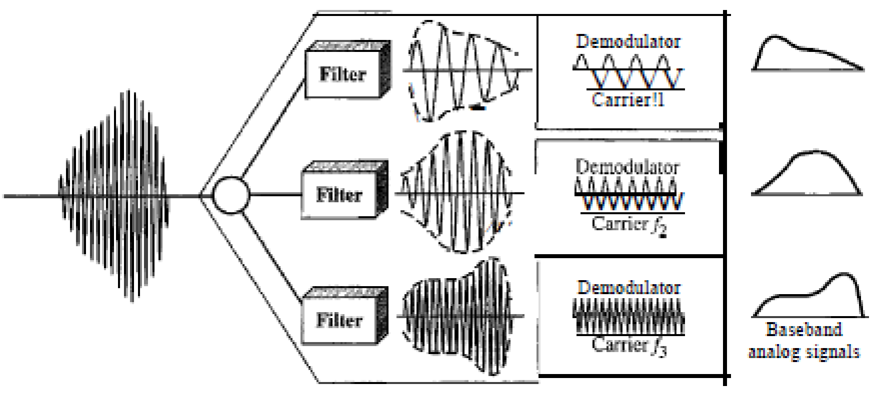


There are three basic multiplexing techniques: frequency-division multiplexing, wavelength-division multiplexing, and time-division multiplexing. The first two are techniques designed for analog signals, the third, for digital signals (see Figure 6.2).

Demultiplexing Process

The demultiplexer uses a series of filters to decompose the multiplexed signal into its constituent component signals. The individual signals are then passed to a demodulator that separates them from their carriers and passes them to the output lines. Figure 6.5 is a conceptual illustration of demultiplexing process.

Figure 6.5 *FDM demultiplexing example*

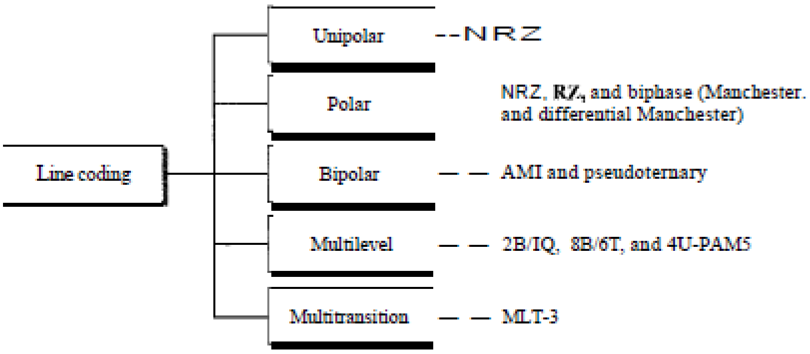


Que-2. Draw the NRZ, NRZ-I and Manchester encoding Scheme for the BIT Pattern 1101001011.

Line Coding Schemes

We can roughly divide line coding schemes into five broad categories, as shown in Figure 4.4.

Figure 4.4 *Line coding schemes*



There are several schemes in each category. We need to be familiar with all schemes discussed in this section to understand the rest of the book. This section can be used as a reference for schemes encountered later.

Unipolar Scheme

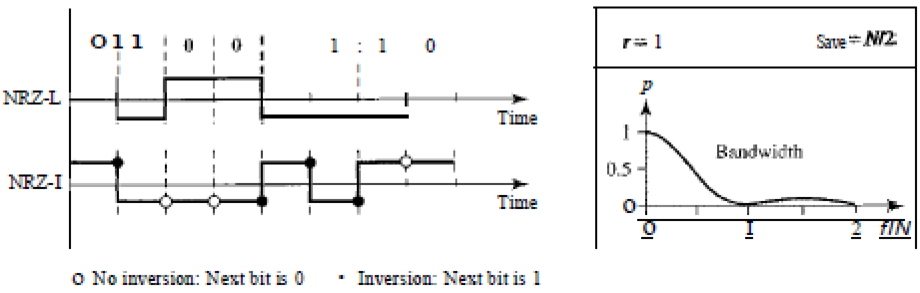
In a unipolar scheme, all the signal levels are on one side of the time axis, either above or below.

NRZ (Non-Return-to-Zero) Traditionally, a unipolar scheme was designed as a non-return-to-zero (NRZ) scheme in which the positive voltage defines bit I and the zero voltage defines bit 0. It is called NRZ because the signal does not return to zero at the middle of the bit. Figure 4.5 show a unipolar NRZ scheme.

Non-Return-to-Zero (NRZ)

In polar NRZ encoding, we use two levels of voltage amplitude. We can have two versions of polar NRZ: NRZ-Land NRZ-I, as shown in Figure 4.6. The figure also shows the value of *r*, the average baud rate, and the bandwidth. In the first variation, NRZ-L (NRZ-Level), the level of the voltage determines the value of the bit. In the second variation, NRZ-I (NRZ-Invert), the change or lack of change in the level of the voltage determines the value of the bit. If there is no change, the bit is 0; if there is a change, the bit is 1.

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

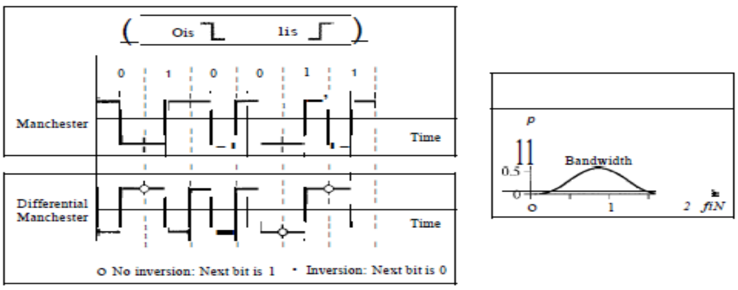


In NRZ-L the level of the voltage determines the value of the bit. In NRZ-I the inversion or the lack of inversion determines the value of the bit.

Biphase: Manchester and Differential Manchester

The idea of RZ (transition at the middle of the bit) and the idea of NRZ-L are combined into the Manchester scheme. In Manchester enco ding, the duration of the bit is divided into two halves. The voltage remains at one level during the first half and moves to the other level in the second half. The transition at the middle of the bit provides synchronization.

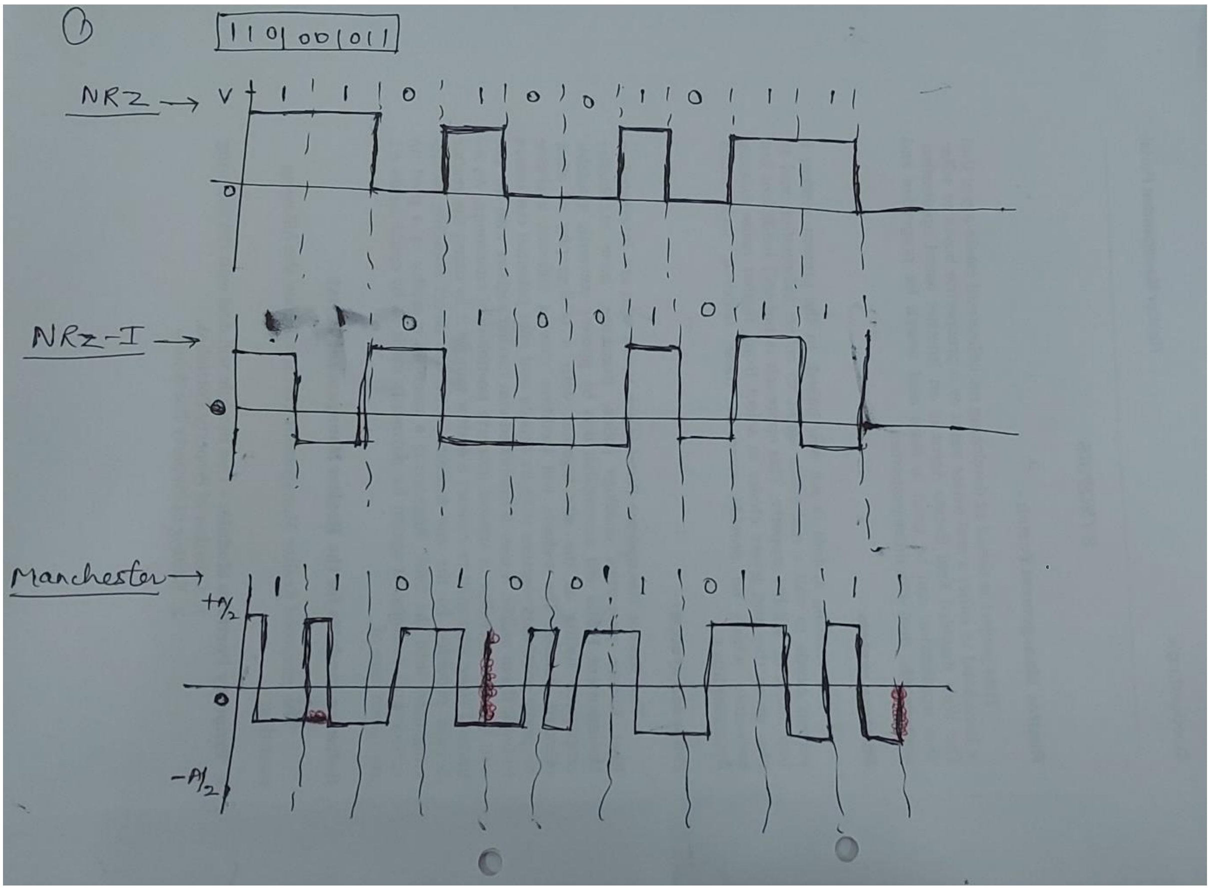
Figure 4.8 *Polar biphase: Manchester and differential Manchester schemes*



In Manchester and differential Manchester encoding, the transition at the middle of the bit is used for synchronization.

The Manchester scheme overcomes several problems associated with NRZ-L, and differential Manchester overcomes several problems associated with NRZ-I. First, there is no baseline wandering. There is no DC component because each bit has a positive and

negative voltage contribution. The only drawback is the signal rate. The signal rate for Manchester and differential Manchester is double that for NRZ. The reason is that there is always one transition at the middle of the bit and maybe one transition at the end of each bit. Figure 4.8 shows both Manchester and differential Manchester encoding schemes. Note that Manchester and differential Manchester schemes are also called biphase



Que-3. Explain working of FDM with its Limitations?

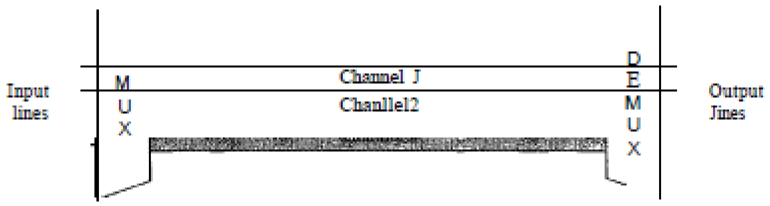
Frequency-Division Multiplexing

Frequency-division multiplexing (FDM) is an analog technique that can be applied when the bandwidth of a link (in hertz) is greater than the combined bandwidths of the signals to be transmitted. In FOM, 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 sufficient bandwidth to accommodate the modulated signal. These bandwidth ranges are the channels through which the various signals travel. Channels can be separated by

strips of unused bandwidth-guard bands-to prevent signals from overlapping. In addition, carrier frequencies must not interfere with the original data frequencies.

Figure 6.3 gives a conceptual view of FDM. In this illustration, the transmission path is divided into three parts, each representing a channel that carries one transmission.

Figure 6.3 *Frequency-division multiplexing*



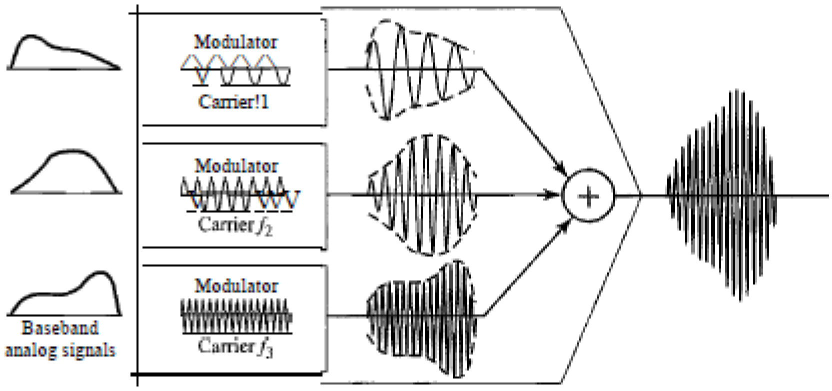
We consider FDM to be an analog multiplexing technique; however, this does not mean that FDM cannot be used to combine sources sending digital signals. A digital signal can be converted to an analog signal (with the techniques discussed in Chapter 5) before FDM is used to multiplex them.

FDM is an analog multiplexing technique that combines analog signals.

Multiplexing Process

Figure 6.4 is a conceptual illustration of the multiplexing process. Each source generates a signal of a similar frequency range. Inside the multiplexer, these similar signals modulates different carrier frequencies (f_1, f_2, and f_3). 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.

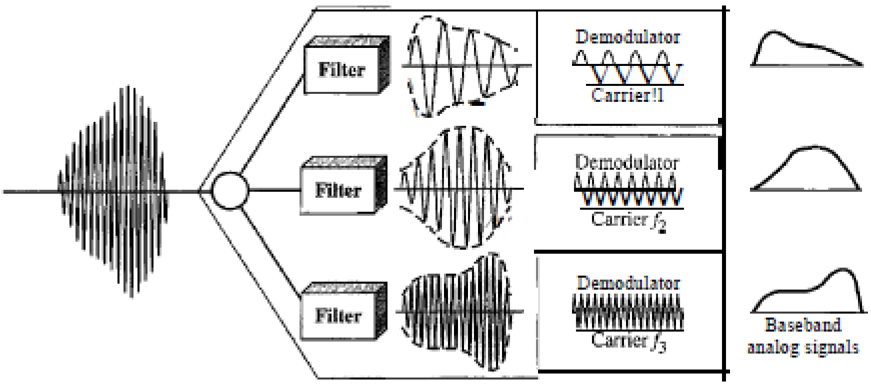
Figure 6.4 *FDM process*



Demultiplexing Process

The demultiplexer uses a series of filters to decompose the multiplexed signal into its constituent component signals. The individual signals are then passed to a demodulator that separates them from their carriers and passes them to the output lines. Figure 6.5 is a conceptual illustration of demultiplexing process.

Figure 6.5 *FDM demultiplexing example*



Other Applications of FDM

A very common application of FDM is AM and FM radio broadcasting. Radio uses the air as the transmission medium. A special band from 530 to 1700 kHz is assigned to AM radio. All radio stations need to share this band. As discussed in Chapter 5, each AM station needs 10kHz of bandwidth. Each station uses a different carrier frequency, which means it is shifting its signal and multiplexing. The signal that goes to the air is a combination of signals. A receiver receives all these signals, but filters (by tuning) only the one which is desired. Without multiplexing, only one AM station could broadcast to the common link, the air. However, we need to know that there is physical multiplexer or demultiplexer here. As we will see in Chapter 12 multiplexing is done at the data link layer.

The situation is similar in FM broadcasting. However, FM has a wider band of 88 to 108 MHz because each station needs a bandwidth of 200 kHz.

Another common use of FDM is in television broadcasting. Each TV channel has its own bandwidth of 6 MHz.

The first generation of cellular telephones (still in operation) also uses FDM. Each user is assigned two 30-kHz channels, one for sending voice and the other for receiving. The voice signal, which has a bandwidth of 3 kHz (from 300 to 3300 Hz), is modulated by using FM. Remember that an FM signal has a bandwidth 10 times that of the modulating signal, which means each channel has 30 kHz (10 x 3) of bandwidth. Therefore, each user is given, by the base station, a 60-kHz bandwidth in a range available at the time of the call.

Que-4. With an Example network, Explain Datagram Forwarding (Table) and datagram Networks characteristics.

8.2 DATAGRAM NETWORKS

In data communications, we need to send messages from one end system to another. If the message is going to pass through a packet-switched network, it needs to be divided into packets of fixed or variable size. The size of the packet is determined by the network and the governing protocol.

In packet switching, there is no resource allocation for a packet. This means that there is no reserved bandwidth on the links, and there is no scheduled processing time

for each packet. Resources are allocated on demand. The allocation is done on a first-come, first-served basis. When a switch receives a packet, no matter what is the source or destination, the packet must wait if there are other packets being processed. As with other systems in our daily life, this lack of reservation may create delay. For example, if we do not have a reservation at a restaurant, we might have to wait.

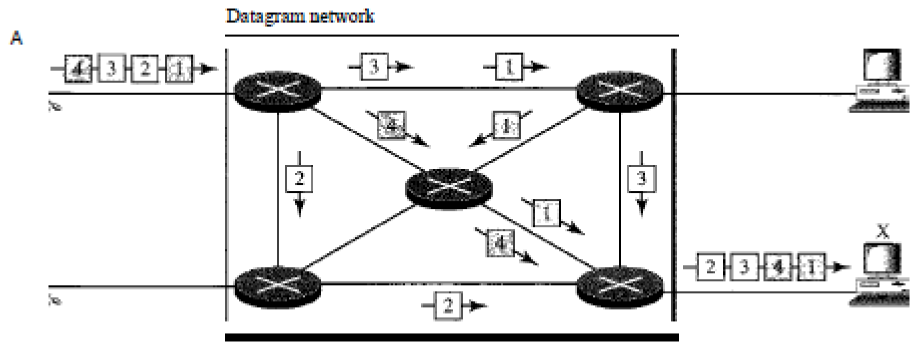
In a packet-switched network, there is no resource reservation; resources are allocated on demand.

In a datagram network, each packet is treated independently of all others. Even if a packet is part of a multipacket transmission, the network treats it as though it existed alone. Packets in this approach are referred to as datagrams.

Datagram switching is normally done at the network layer. We briefly discuss datagram networks here as a comparison with circuit-switched and virtual-circuit-switched networks. In Part 4 of this text, we go into greater detail.

Figure 8.7 shows how the datagram approach is used to deliver four packets from station A to station X. The switches in a datagram network are traditionally referred to as routers. That is why we use a different symbol for the switches in the figure.

Figure 8.7 *A datagram network with four switches (routers)*



In this example, all four packets (or datagrams) belong to the same message, but may travel different paths to reach their destination. This is so because the links may be involved in carrying packets from other sources and do not have the necessary bandwidth available to carry all the packets from A to X. This approach can cause the datagrams of a transmission to arrive at their destination out of order with different delays between the packets. Packets may also be lost or dropped because of a lack of resources. In most protocols, it is the responsibility of an upper-layer protocol to reorder the datagrams or ask for lost datagrams before passing them on to the application.

The datagram networks are sometimes referred to as connectionless networks. The term *connectionless* here means that the switch (packet switch) does not keep information about the connection state. There are no setup or teardown phases. Each packet is treated the same by a switch regardless of its source or destination.

Routing Table

If there are no setup or teardown phases, how are the packets routed to their destinations in a datagram network? In this type of network, each switch (or packet switch) has a routing table which is based on the destination address. The routing tables are dynamic and are updated periodically. The destination addresses and the corresponding forwarding output ports are recorded in the tables. This is different from the table of a circuit-switched network in which each entry is created when the setup phase is completed and deleted when the teardown phase is over. Figure 8.8 shows the routing table for a switch.

Figure 8.8 *Routing table in a datagram network*

Destination address	Output port
1232	1
4150	2
.	.
9130	3

A switch in a datagram network uses a routing table that is based on the destination address.

Destination Address

Every packet in a datagram network carries a header that contains, among other information, the destination address of the packet. When the switch receives the packet, this destination address is examined; the routing table is consulted to find the corresponding port through which the packet should be forwarded. This address, unlike the address in a virtual-circuit-switched network, remains the same during the entire journey of the packet.

The destination address in the header of a packet in a datagram network remains the same during the entire journey of the packet.

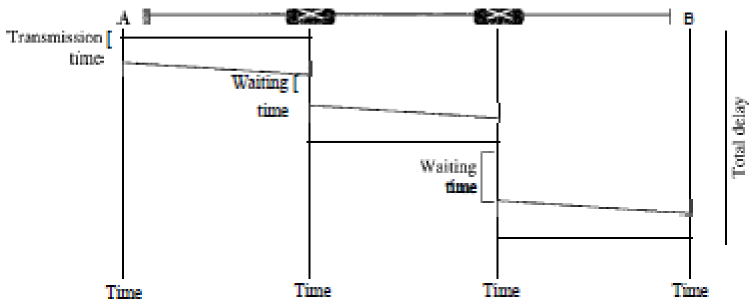
Efficiency

The efficiency of a datagram network is better than that of a circuit-switched network; resources are allocated only when there are packets to be transferred. If a source sends a packet and there is a delay of a few minutes before another packet can be sent, the resources can be reallocated during these minutes for other packets from other sources.

Delay

There may be greater delay in a datagram network than in a virtual-circuit network. Although there are no setup and teardown phases, each packet may experience a wait at a switch before it is forwarded. In addition, since not all packets in a message necessarily travel through the same switches, the delay is not uniform for the packets of a message. Figure 8.9 gives an example of delay in a datagram network for one single packet.

Figure 8.9 *Delay in a datagram network*



The packet travels through two switches. There are three transmission times $(3T)$, three propagation delays (slopes 3τ of the lines), and two waiting times $(w_1 + w_2)$. We ignore the processing time in each switch. The total delay is

$$\text{Total delay} = 3T + 3\tau + w_1 + w_2$$

Datagram Networks in the Internet

As we will see in future chapters, the Internet has chosen the datagram approach to switching at the network layer. It uses the universal addresses defined in the network layer to route packets from the source to the destination.

Switching in the Internet is done by using the datagram approach to packet switching at the network layer.

Que-5. Compare and Contrast a Circuit Switched Networks and Packet Switched Networks.

Difference between Circuit Switching and Packet Switching:

Circuit Switching	Packet Switching
In-circuit switching has there are 3 phases: i) Connection Establishment. ii) Data Transfer. iii) Connection Released.	In Packet switching directly data transfer takes place.
In-circuit switching, each data unit knows the entire path address which is provided by the source.	In Packet switching, each data unit just knows the final destination address intermediate path is decided by the routers.
In-Circuit switching, data is processed at the source system only	In Packet switching, data is processed at all intermediate nodes including the source system.
The delay between data units in circuit switching is uniform.	The delay between data units in packet switching is not uniform.

Resource reservation is the feature of circuit switching because the path is fixed for data transmission.	There is no resource reservation because bandwidth is shared among users.
Circuit switching is more reliable.	Packet switching is less reliable.
Wastage of resources is more in Circuit Switching	Less wastage of resources as compared to Circuit Switching
It is not a store and forward technique.	It is a store and forward technique.
Transmission of the data is done by the source.	Transmission of the data is done not only by the source but also by the intermediate routers.
Congestion can occur during the connection establishment phase because there might be a case where a request is being made for a channel but the channel is already occupied.	Congestion can occur during the data transfer phase, a large number of packets comes in no time.
Circuit switching is not convenient for handling bilateral traffic.	Packet switching is suitable for handling bilateral traffic.
In-Circuit switching, the charge depends on time and distance, not on traffic in the network.	In Packet switching, the charge is based on the number of bytes and connection time.
Recording of packets is never possible in circuit switching.	Recording of packets is possible in packet switching.
In-Circuit Switching there is a physical path between the source and the destination	In Packet Switching there is no physical path between the source and the destination
Circuit Switching does not support store and forward transmission	Packet Switching supports store and forward transmission
Call setup is required in circuit switching.	No call setup is required in packet switching.

In-circuit switching each packet follows the same route.	In packet switching packets can follow any route.
The circuit switching network is implemented at the physical layer.	Packet switching is implemented at the datalink layer and network layer
Circuit switching requires simple protocols for delivery.	Packet switching requires complex protocols for delivery.

Que-6. What is the role of the address field in a packet travelling through a Virtual Circuit Networks?

8.3 VIRTUAL-CIRCUIT NETWORKS

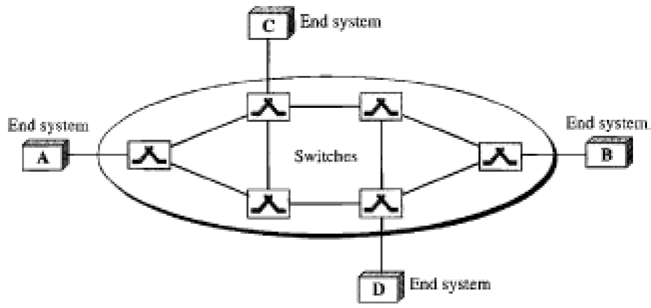
A virtual-circuit network is a cross between a circuit-switched network and a datagram network. It has some characteristics of both.

1. As in a circuit-switched network, there are setup and teardown phases in addition to the data transfer phase.

2. Resources can be allocated during the setup phase, as in a circuit-switched network, or on demand, as in a datagram network.
3. As in a datagram network, data are packetized and each packet carries an address in the header. However, the address in the header has local jurisdiction (it defines what should be the next switch and the channel on which the packet is being canied), not end-to-end jurisdiction. The reader may ask how the intermediate switches know where to send the packet if there is no final destination address carried by a packet. The answer will be clear when we discuss virtual-circuit identifiers in the next section.
4. As in a circuit-switched network, all packets follow the same path established during the connection.
5. 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. But this may change in the future.

Figure 8.10 is an example of a virtual-circuit network. The network has switches that allow traffic from sources to destinations. A source or destination can be a computer, packet switch, bridge, or any other device that connects other networks.

Figure 8.10 *Virtual-circuit network*



Addressing

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

Global Addressing

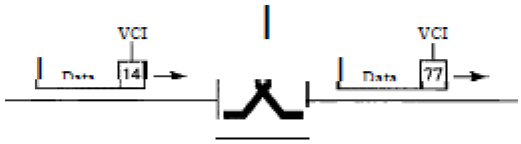
A source or a destination needs to have a global address-an address that can be unique in the scope of the network or internationally if the network is part of an international network. However, we will see that a global address in virtual-circuit networks is used only to create a virtual-circuit identifier, as discussed next.

Virtual-Circuit Identifier

The identifier that is actually used for data transfer is called the virtual-circuit identifier (Vel). A vel, unlike a global address, is a small number that has only switch scope; it

is used by a frame between two switches. When a frame arrives at a switch, it has a VCI; when it leaves, it has a different VCl. Figure 8.11 shows how the VCI in a data frame changes from one switch to another. Note that a VCI does not need to be a large number since each switch can use its own unique set of VCIs.

Figure 8.11 *Virtual-circuit identifier*



Three Phases

As in a circuit-switched network, a source and destination need to go through three phases in a virtual-circuit network: setup, data transfer, and teardown. In the setup phase, the source and destination use their global addresses to help switches make table entries for the connection. In the teardown phase, the source and destination inform the switches to delete the corresponding entry. Data transfer occurs between these two phases. We first discuss the data transfer phase, which is more straightforward; we then talk about the setup and teardown phases.

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 table, in its simplest form, has four columns. This means that the switch holds four pieces of information for each virtual circuit that is already set up. We show later how the switches make their table entries, but for the moment we assume that each switch has a table with entries for all active virtual circuits. Figure 8.12 shows such a switch and its corresponding table.

Figure 8.12 shows a frame arriving at port 1 with a VCI of 14. When the frame arrives, the switch looks in its table to find port 1 and a VCI of 14. When it is found, the switch knows to change the VCI to 22 and send out the frame from port 3.

Figure 8.13 shows how a frame from source A reaches destination B and how its VCI changes during the trip. Each switch changes the VCI and routes the frame.

The data transfer phase is active until the source sends all its frames to the destination. The procedure at the switch is the same for each frame of a message. 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.

Figure 8.12 *Switch and tables in a virtual-circuit network*

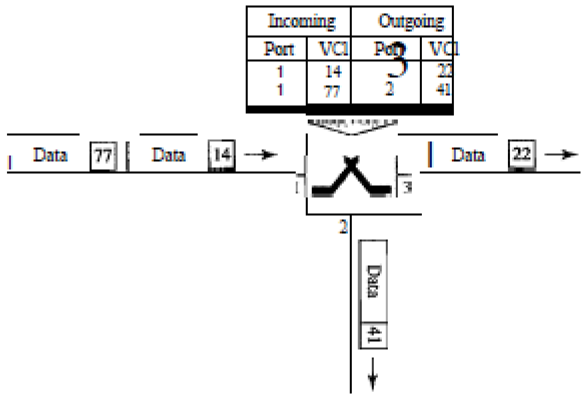
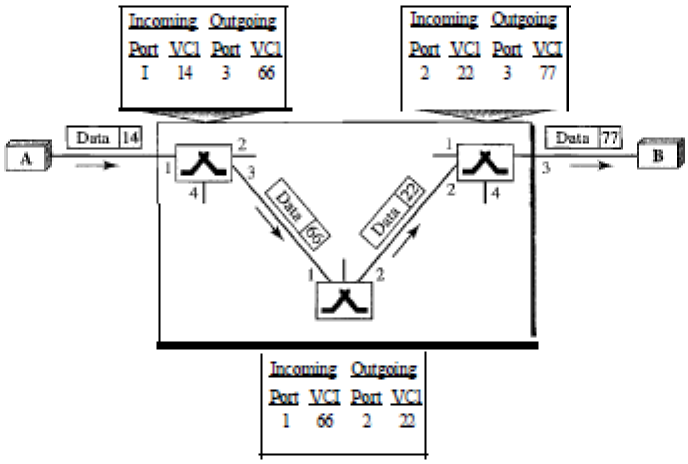


Figure 8.13 *Source-to-destination data transfer in a virtual-circuit network*



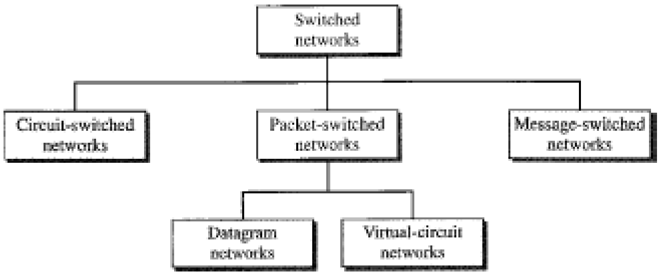
Teardowil Phase

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.

Que-7. List the three Traditional Switching Methods. What are the most common today?

Traditionally, three methods of switching have been important: circuit switching, packet switching, and message switching. The first two are commonly used today. The third has been phased out in general communications but still has networking applications. We can then divide today's networks into three broad categories: circuit-switched networks, packet-switched networks, and message-switched. Packet-switched networks can funher be divided into two subcategories-virtual-circuit networks and datagram networks- as shown in Figure 8.2.

Figure 8.2 *Taxonomy ofswitched networks*



We can say that the virtual-circuit networks have some common characteristics with circuit-switched and datagram networks. Thus, we first discuss circuit-switched networks, then datagram networks, and finally virtual-circuit networks.

Today the tendency in packet switching is to combine datagram networks and virtual-circuit networks. Networks route the first packet based on the datagram addressing idea, but then create a virtual-circuit network for the rest of the packets coming from the same source and going to the same destination. We will see some of these networks in future chapters.

In message switching, each switch stores the whole message and forwards it to the next switch. Although, we don't see message switching at lower layers, it is still used in some applications like electronic mail (e-mail). We will not discuss this topic in this book.

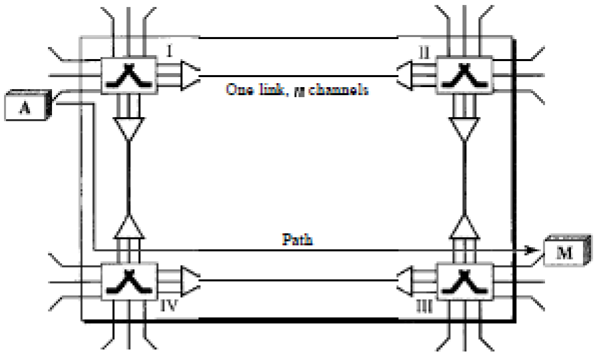
8.1 CIRCUIT-SWITCHED NETWORKS

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. How ever, each connection uses only one dedicated channel on each link. Each link is nor mally divided into n channels by using FDM or TDM as discussed in Chapter 6.

A circuit-switched network is made of a set of switches connected by physical links, in which each link is divided into n channels.

Figure 8.3 shows a trivial circuit-switched network with four switches and fou links. Each link is divided into n (n is 3 in the figure) channels by using FDM or TDM

Figure 8.3 *A trivial circuit-switched network*



We have explicitly shown the multiplexing symbols to emphasize the division of the link into channels even though multiplexing can be implicitly included in the switch fabric.

The end systems, such as computers or telephones, are directly connected to a switch. We have shown only two end systems for simplicity. When end system A needs to communicate with end system M, system A needs to request a connection to M that must be accepted by all switches as well as by M itself. This is called the setup phase; a circuit (channel) is reserved on each link, and the combination of circuits or channels defines the dedicated path. After the dedicated path made of connected circuits (channels) is established, data transfer can take place. After all data have been transferred, the circuits are tom down.

We need to emphasize several points here:

D Circuit switching takes place at the physical layer.

D Before starting communication, the stations must make a reservation for the resources to be used during the communication. These resources, such as channels (bandwidth in FDM and time slots in TDM), switch buffers, switch processing time, and switch input/output ports, must remain dedicated during the entire duration of data transfer until the teardown phase.

D Data transferred between the two stations are not packetized (physical layer transfer of the signal). The data are a continuous flow sent by the source station and received by the destination station, although there may be periods of silence.

D There is no addressing involved during data transfer. The switches route the data based on their occupied band (FDM) or time slot (TDM). Of course, there is end-to-end addressing used during the setup phase, as we will see shortly.

In circuit switching, the resources need to be reserved during the setup phase;
the resources remain dedicated for the entire duration
of data transfer until the teardown phase.

The end systems, such as computers or telephones, are directly connected to a switch. We have shown only two end systems for simplicity. When end system A needs to communicate with end system M, system A needs to request a connection to M that must be accepted by all switches as well as by M itself. This is called the setup phase; a circuit (channel) is reserved on each link, and the combination of circuits or channels defines the dedicated path. After the dedicated path made of connected circuits (channels) is established, data transfer can take place. After all data have been transferred, the circuits are tom down.

We need to emphasize several points here:

D Circuit switching takes place at the physical layer.

D Before starting communication, the stations must make a reservation for the resources to be used during the communication. These resources, such as channels (bandwidth in FDM and time slots in TDM), switch buffers, switch processing time, and switch input/output ports, must remain dedicated during the entire duration of data transfer until the teardown phase.

D Data transferred between the two stations are not packetized (physical layer transfer of the signal). The data are a continuous flow sent by the source station and received by the destination station, although there may be periods of silence.

D There is no addressing involved during data transfer. The switches route the data based on their occupied band (FDM) or time slot (TDM). Of course, there is end-to-end addressing used during the setup phase, as we will see shortly.

In circuit switching, the resources need to be reserved during the setup phase;
the resources remain dedicated for the entire duration
of data transfer until the teardown phase.

8.2 DATAGRAM NETWORKS

In data communications, we need to send messages from one end system to another. If the message is going to pass through a packet-switched network, it needs to be divided into packets of fixed or variable size. The size of the packet is determined by the network and the governing protocol.

In packet switching, there is no resource allocation for a packet. This means that there is no reserved bandwidth on the links, and there is no scheduled processing time

for each packet. Resources are allocated on demand. The allocation is done on a first-come, first-served basis. When a switch receives a packet, no matter what is the source or destination, the packet must wait if there are other packets being processed. As with other systems in our daily life, this lack of reservation may create delay. For example, if we do not have a reservation at a restaurant, we might have to wait.

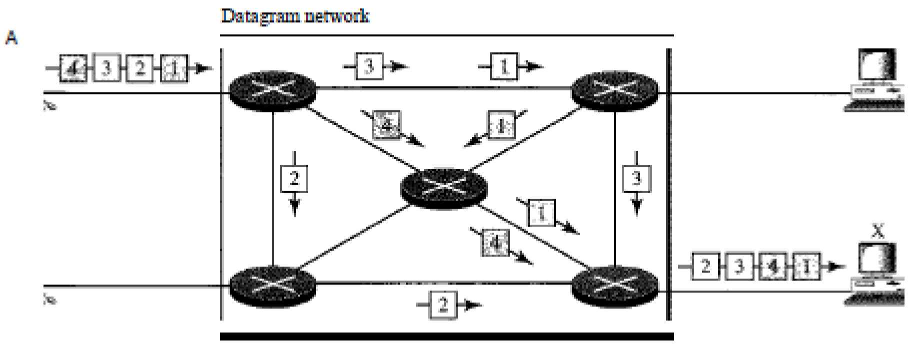
In a packet-switched network, there is no resource reservation; resources are allocated on demand.

In a datagram network, each packet is treated independently of all others. Even if a packet is part of a multipacket transmission, the network treats it as though it existed alone. Packets in this approach are referred to as datagrams.

Datagram switching is normally done at the network layer. We briefly discuss datagram networks here as a comparison with circuit-switched and virtual-circuit-switched networks. In Part 4 of this text, we go into greater detail.

Figure 8.7 shows how the datagram approach is used to deliver four packets from station A to station X. The switches in a datagram network are traditionally referred to as routers. That is why we use a different symbol for the switches in the figure.

Figure 8.7 *A datagram network with four switches (routers)*



In this example, all four packets (or datagrams) belong to the same message, but may travel different paths to reach their destination. This is so because the links may be involved in carrying packets from other sources and do not have the necessary bandwidth available to carry all the packets from A to X. This approach can cause the datagrams of a transmission to arrive at their destination out of order with different delays between the packets. Packets may also be lost or dropped because of a lack of resources. In most protocols, it is the responsibility of an upper-layer protocol to reorder the datagrams or ask for lost datagrams before passing them on to the application.

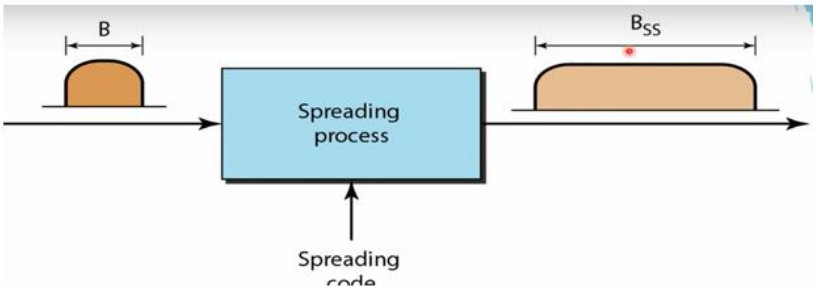
Que-8. Define Spread Spectrum and its goal. List the two spread spectrum techniques to achieve bandwidth spreading.

SPREAD SPECTRUM :

- • Multiplexing combines signals from several sources to achieve bandwidth efficiency; the available bandwidth of a link is divided between the sources.
- • In spread spectrum (88), we also combine signals from different sources to fit into a larger bandwidth, but our goals are somewhat different.
- • Spread spectrum is designed to used in wireless applications (LANs and WANs).
- • In wireless applications, all stations use air (or a vacuum) as the medium for communication.
- • Stations must be able to share this medium without interception by an eavesdropper and without being subject to jamming from a malicious intruder (in military operations, for example).

- •Spread spectrum achieves its goals through two principles:
- 1.The band width located to each station need strobe, by far, larger than what is needed. This allows redundancy.
- 2. The expanding of the original bandwidth B to the bandwidth Bss must be done by a process that is independent of the original signal.
- In other words, the spreading process occurs after the signal is created by the source.

After the signal is created by the source, the spreading process uses a spreading code and spreads the bandwidth.



There are two techniques to spread the bandwidth:
frequency hopping spread spectrum (FHSS)
direct sequence spread spectrum (DSSS).

Frequency Hopping Spread Spectrum (FHSS) :

- The frequency hopping spread spectrum (FHSS) technique uses M different carrier frequencies that are modulated by the source signal.
- At one moment, the signal modulates one carrier frequency; at the next moment, the signal modulates another frequency.
- Although the modulation is done using one carrier frequency at a time, M frequencies are used in the long run.
- The bandwidth occupied by a source after spreading is BpHSS »B.

Figure 6.28 *Frequency hopping spread spectrum (FHSS)*

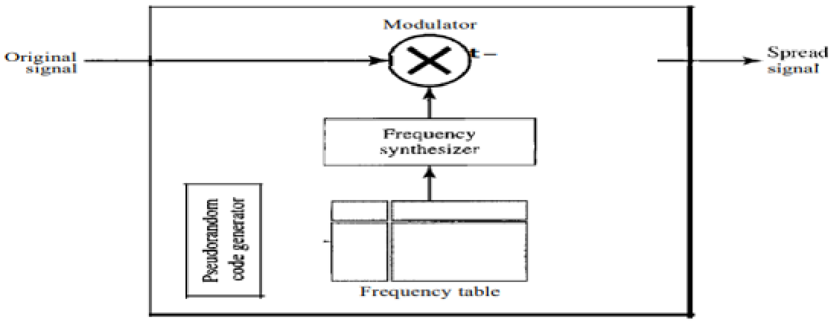
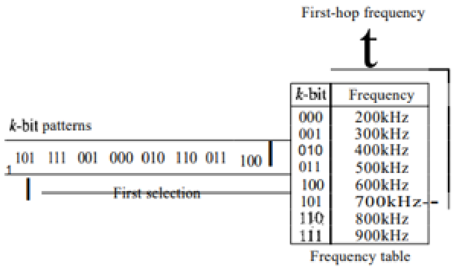


Figure 6.29 *Frequency selection in FHSS*



- A pseudorandom code generator, called pseudorandom noise (PN), creates a k-bit pattern for every hopping period Th
- The frequency table uses the pattern to find the frequency to be used for this hopping period and passes it to the frequency synthesizer.
- The frequency synthesizer creates a carrier signal of that frequency, and the source signal modulates the carrier signal.
- Suppose we have decided to have eight hopping frequencies. In this case, M is 8 and k is 3. The pseudorandom code generator will create eight different 3-bit patterns. These are mapped to eight different frequencies in the frequency table.
- the pattern is pseudorandom it is repeated after eight hoppings.

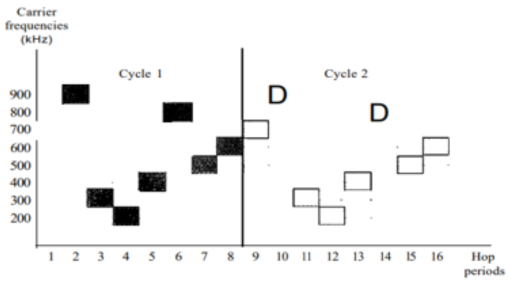
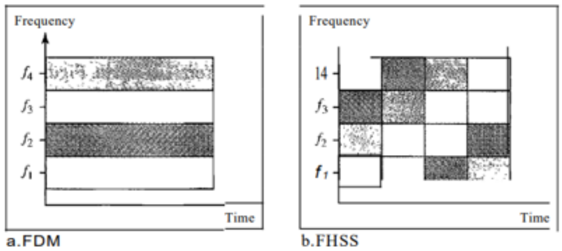


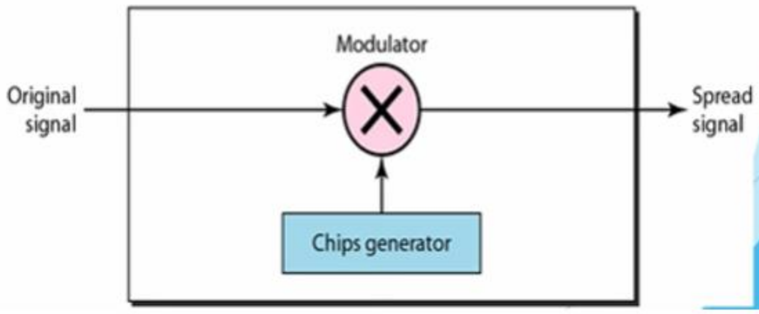
Figure 6.31 *Bandwidth sharing*



If the number of hopping frequencies is M, we can multiplex M channels into one by using the same Bss bandwidth

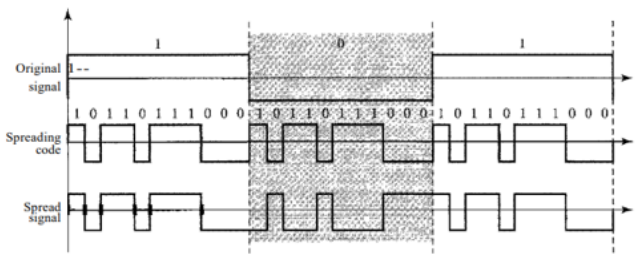
Direct Sequence Spread Spectrum

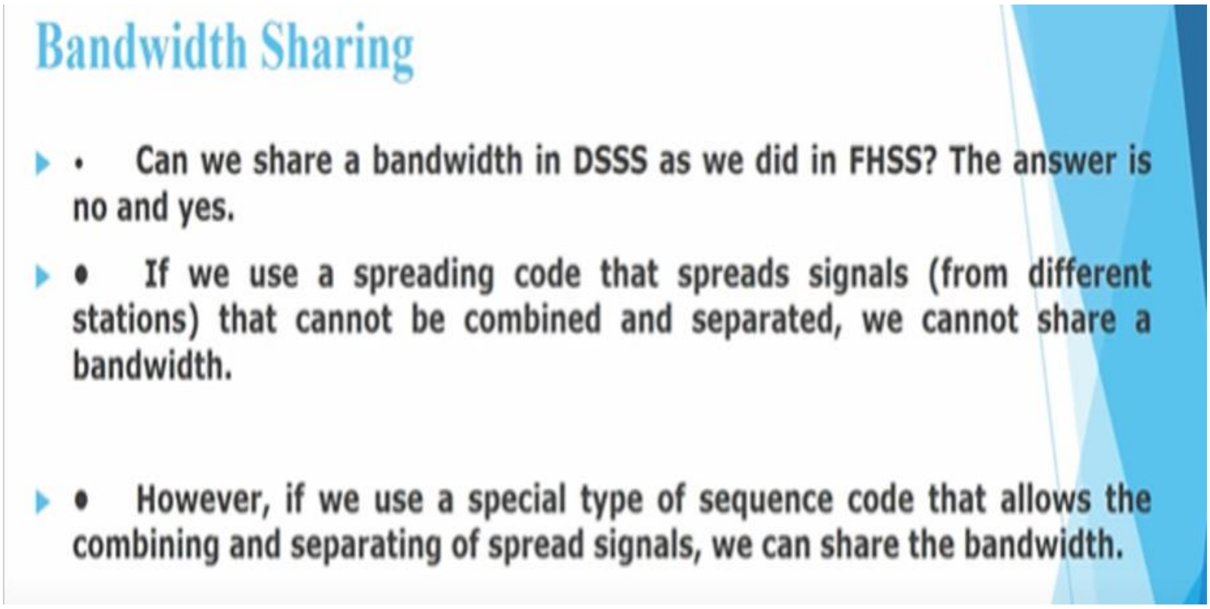
- **The direct sequence spread spectrum (DSSS) technique also expands the bandwidth of the original signal, but the process is different.**
- **In DSSS, we replace each data bit with 'n' bits using a spreading code**
- **In other words, each bit is assigned a code of n bits, called chips, where the chip rate is n times that of the data bit**



- Example :
- let us consider the sequence used in a wireless LAN, the famous Barker sequence where n is 11.
- We assume that the original signal and the chips in the chip generator use polar NRZ encoding.
- Figure 6.33 shows the chips and the result of multiplying the original data by the chips to get the spread signal.
- If the original signal rate is N, the rate of the spread signal is llN. This means that the required bandwidth for the spread signal is 11 times larger than the bandwidth of the original signal.

Figure 6.33 *DSSS example*

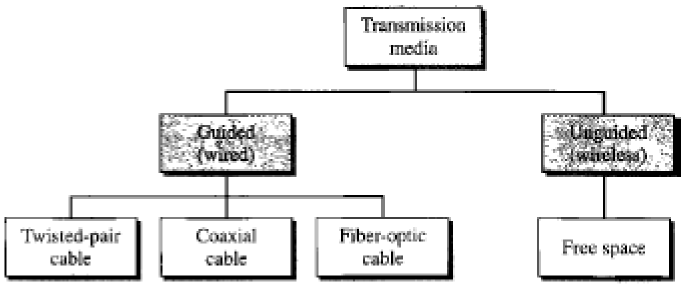




Que-9. What are the three major categories of Guided Media? Explain with Diagram.

In telecommunications, transmission media can be divided into two broad categories: guided and unguided. Guided media include twisted-pair cable, coaxial cable, and fiber-optic cable. Unguided medium is free space. Figure 7.2 shows this taxonomy.

Figure 7.2 *Classes of transmission media*

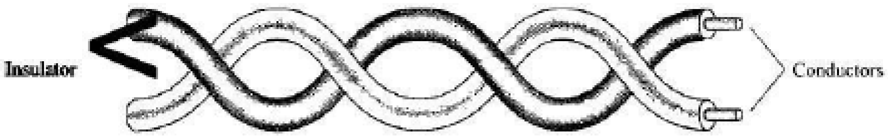


7.1 GUIDED MEDIA

Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable. A signal traveling along any of these media is directed and contained by the physical limits of the medium. Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current. Optical fiber is a cable that accepts and transports signals in the form of light.

Twisted-Pair Cable

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together, as shown in below figure.



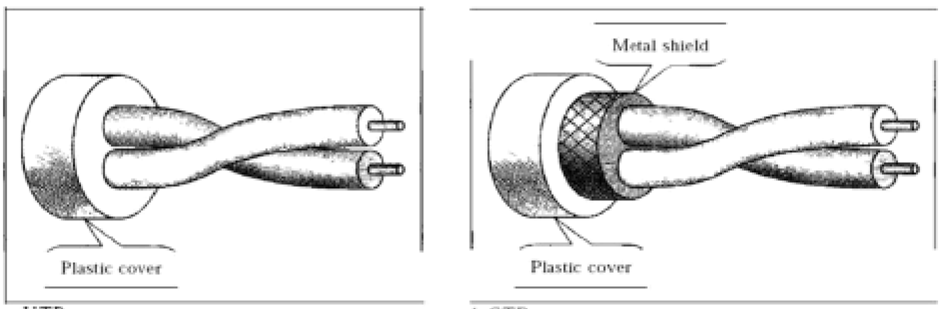
One of the wires is used to carry signals to the receiver, and the other is used only as a ground reference. The receiver uses the difference between the two.

In addition to the signal sent by the sender on one of the wires, interference (noise) and crosstalk may affect both wires and create unwanted signals.

Unshielded Versus Shielded Twisted-Pair Cable

The most common twisted-pair cable used in communications is referred to as unshielded twisted-pair (UTP).

IBM has also produced a version of twisted-pair cable for its use called shielded twisted-pair (STP).



a.UTP b.STP

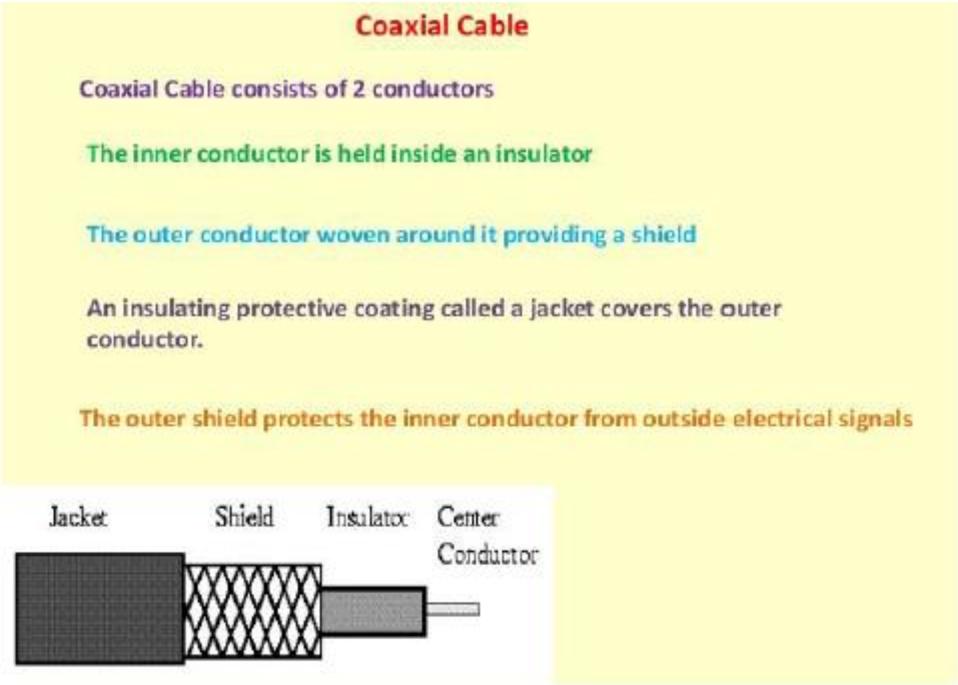
STP cable has a metal foil or braided mesh covering that encases each pair of insulated conductors. Although metal casing improves the quality of cable by preventing the penetration of **noise** or crosstalk, it is **bulkier** and **more expensive**.

Applications

Twisted-pair cables are used in telephone lines to provide voice and data channels.

The local loop-the line that connects subscribers to the central telephone office – commonly consists of unshielded twisted-pair cables.

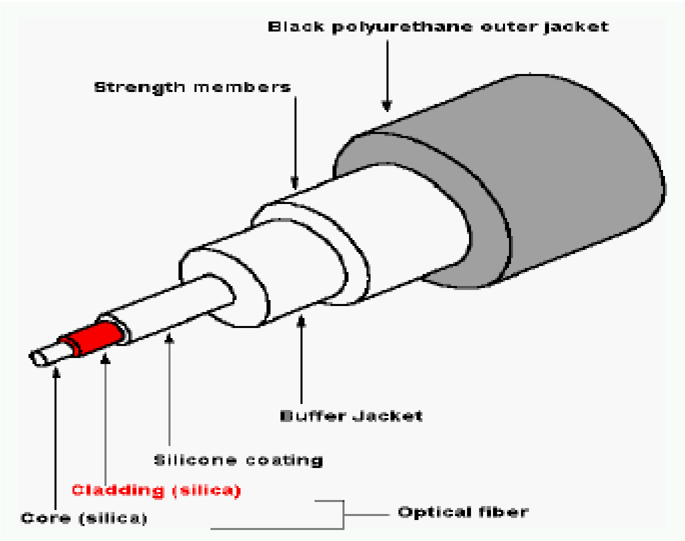
The DSL lines that are used by the telephone companies to provide high-data-rate connections also use the high-bandwidth capability of unshielded twisted-pair cables.



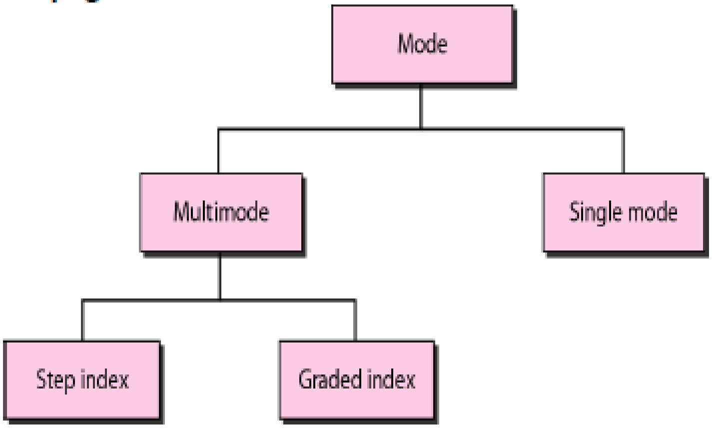
- **A coaxial cable is a type of shielded and insulated copper cable that is used in computer networks and to deliver cable TV services to end users.**
- **The outer conductor acts as a shield against noise and crosstalk. The outer conductor is enclosed and whole cable is protected by a plastic cover.**
- **The distance between the outer conductor and inner conductor plus the type of material used for insulating the inner conductor determine the cable properties.**
- **The most standard coaxial cable connector BNC (Bayone – Neill concelman) connector.**
- **BNC connector is used to connect to the end of the cable to a device(Such as TV).**
- **Used in cable TV networks**
- **Used in analog telephone networks**

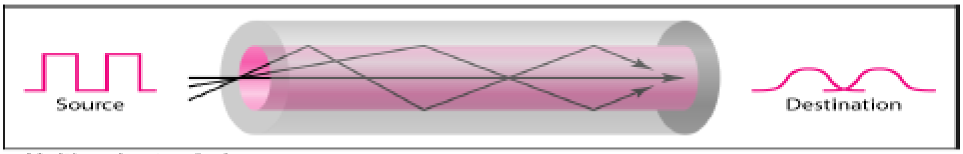
Optical Fibre-

- Optical fiber transmission systems were introduced in 1970. It offered greater advantages over copper based digital transmission systems.
- a thin flexible fiber with a glass core through which light signals can be sent.
- Fiber optic cable has the ability to transmit signals over much longer distances.
- Optical fiber are immune to interference and cross talk

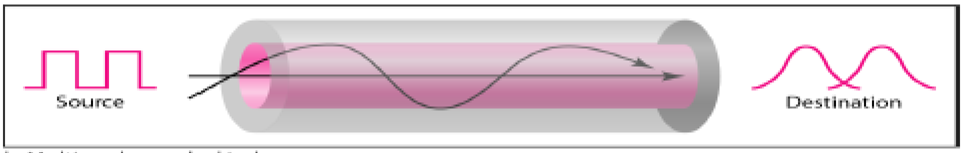


Propogation mode

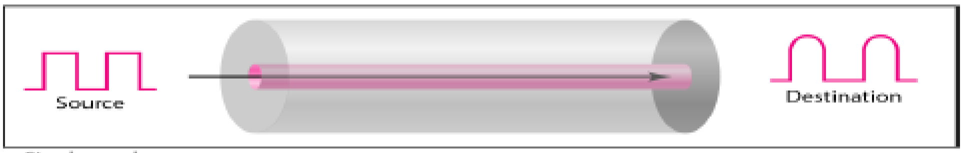




a. Multimode, step index



b. Multimode, graded index



c. Single mode

- A fiber optic cable is made of center glass core surrounded by a concentric layer of glass(cladding).
- The information is transmitted thru the glass core in the form of light.
- An important characteristic of fiber optic is refraction. Refraction is the characteristic of a material to either pass or reflect the light. When a light passes thru the medium, it bends as it passes from one medium to another.
- Wave length Division Multiplexing is an effective approach to explore the bandwidth that is available in optical fiber. In WDM multiple wave length are used to carry several information simultaneously over the same fiber.

Advantages

- It supports higher bandwidth
- It runs greater distance.
- Electromagnetic noise cannot affect fiber optic cables
- Usage of glass makes more resistant than copper

Disadvantages

- Installation and maintenance is difficult.
- Unidirectional light propagation. Two fibers are used for bidirectional propagation.
- The cable and the interfaces are more expensive.

Que-10. Explain any two types of multiplexing with diagram-
A) Frequency Division Multiplexing (Analog)
B) Wave Length Division Multiplexing (Analog)
C) Time Division Multiplexing (Digital)

A) Frequency Division Multiplexing (Analog)

Frequency Division Multiplexing (FDM) :

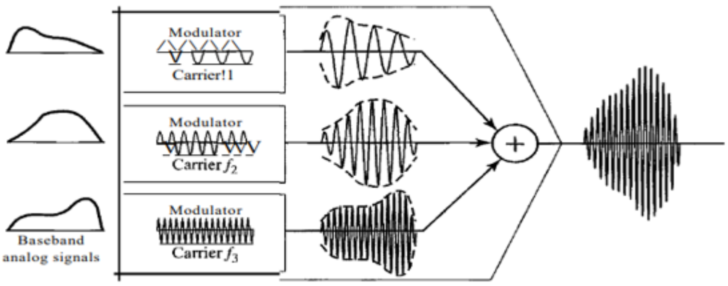
- FDM is an analog multiplexing technique that combines analog signals .
- FDM can be used when the bandwidth of a link is greater than the combined bandwidths of the signals to be transmitted. (Bandwidth measured in hertz).

Multiplexing Process :

• Here is how it works :

1) Each sending-device generates modulated-signals with different carrier-frequencies (f1, f2, & f3).
2) Then, these modulated-signals are combined into a single multiplexed-signal.
3) Finally, the multiplexed-signal is transported by the link.

Figure 6.4 *FDM process*



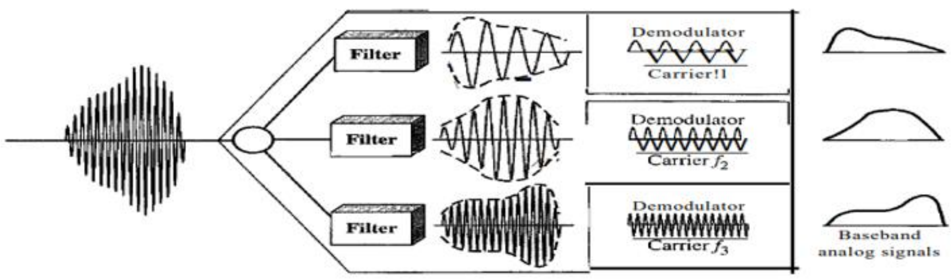
• Carrier-frequencies are separated by sufficient bandwidth to accommodate the modulated-signal.
• Channels can be separated by strips of unused bandwidth called guard bands.
• Guard bands prevent signals from overlapping.
• In addition, carrier-frequencies must not interfere with the original data frequencies.
• Although FDM is considered as analog multiplexing technique, the sources can produce digital-signal.
• The digital-signal can be sampled, changed to analog-signal, and then multiplexed by using FDM.

De multiplexing Process

• Here is how it works :

1) The DE multiplexer uses filters to divide the multiplexed-signal into individual-signals.
2) Then, the individual signals are passed to a demodulator. 3) Finally, the demodulator → separates the individual signals from the carrier signals and → passes the individual signals to the output-lines.

Figure 6.5 *FDM demultiplexing example*



Example : Assume that a voice channel occupies a bandwidth of 4 kHz. We need to combine three voice channels into a link with a bandwidth of 12 kHz, from 20 to 32 kHz. Show the configuration, using the frequency domain. Assume there are no guard bands.

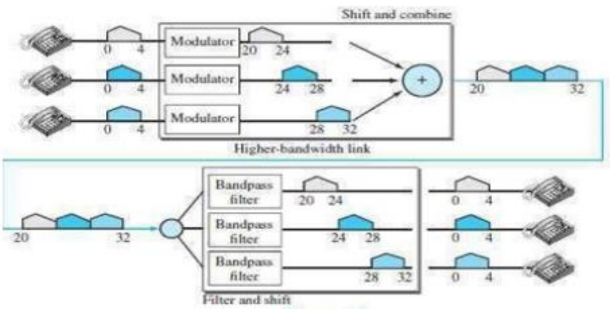


Figure 6.6

B) Wave Length Division Multiplexing (Analog)

Applications of FDM

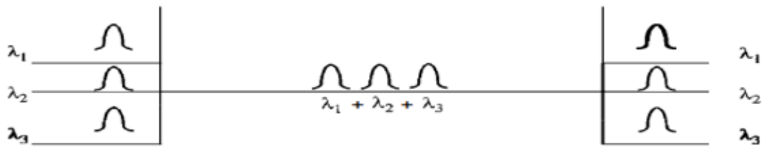
1) To maximize the efficiency of their infrastructure, Telephone-companies have traditionally multiplexed signals from lower-bandwidth lines onto higher-bandwidth lines.
2) A very common application of FDM is AM and FM radio broadcasting.
3) The first generation of cellular telephones (still in operation) also uses FDM.

Wavelength Division Multiplexing (WDM)

- WDM is an analog multiplexing technique that combines analog signals.
- WDM is designed to use the high-data-rate capability of fiber optical-cable.
- The data-rate of optical-cable is higher than the data-rate of metallic-cable.
- Using an optical-cable for one single line wastes the available bandwidth.
- Multiplexing allows combining several lines into one line.
- WDM is same as FDM with 2 exceptions:

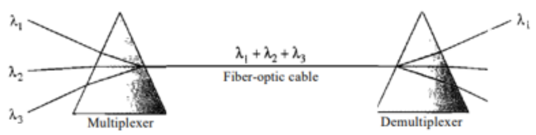
1) Multiplexing & demultiplexing involve optical-signals transmitted through optical-cable.
2) The frequencies are very high.

Figure 6.10 *Wavelength-division multiplexing*



A **multiplexer** combines several narrow-bands of light into a wider-band of light.
A **demultiplexer** divides a wider-band of light into several narrow-bands of light.
A prism is used for combining and splitting of light sources

:Figure 6.11 *Prisms in wavelength-division multiplexing and demultiplexing*



One application of WDM is the SONET network in which multiple optical fiber lines are multiplexed and demultiplexed

C) Time Division Multiplexing (Digital)

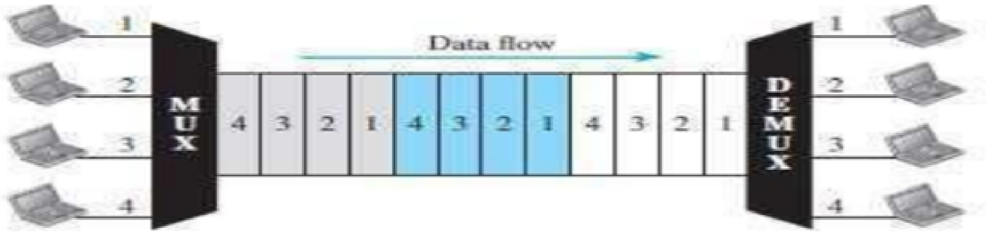
Time Division Multiplexing (TDM)

- TDM is a digital multiplexing technique that combines digital signals
- TDM combines several low-rate channels into one high-rate one.

- FDM vs. TDM

1) In FDM, a portion of the bandwidth is shared.
2) In TDM, a portion of the time is shared.

- Each connection occupies a portion of time in the link.
- Several connections share the high bandwidth of a line.



- As shown in Figure 6.12, the link is divided by time.
- Portions of signals 1, 2, 3, and 4 occupy the link sequentially.

- Digital-data from different sources are combined into one timeshared link.
- Although TDM is considered as digital multiplexing technique, the sources can produce analog-signal.
- The analog data can be sampled, changed to digital-data, and then multiplexed by using TDM.
- Two types of TDM:

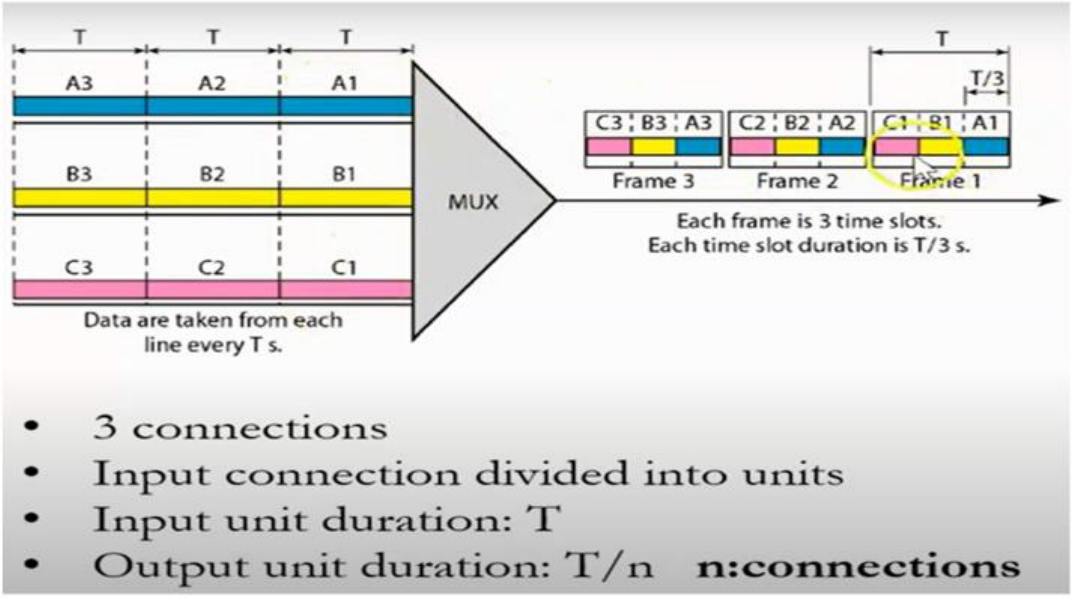
1) Synchronous
2) Statistical.

Synchronous TDM :

Allocate exactly same time slot even though the device is not sending the data.

Time Slots & Frames

- Each input-connection has an allotment in the output-connection even if it is not sending data.
- The data-flow of input-connection is divided into units (Figure 6.13).
- A unit can be 1 bit, 1 character, or 1 block of data.
- Each input-unit occupies one input-time-slot.



• Frame duration= T

Statistical TDM

• Problem: Synchronous TDM is not efficient.

For ex: If a source does not have data to send, the corresponding slot in the output-frame is empty.

Solution: Use statistical TDM. – First come first serve. For active device.

Slots are dynamically allocated to improve bandwidth-efficiency.

Only when an input-line has data to send, the input-line is given a slot in the output-frame.