3.1 OBJECTIVES

The objective of this chapter is to familiarize with : -

i) Concept of LAN

ii) Transmission Media For LAN

iii) Media Access Control

iv) Carrier Sense Multiple Access (CSMA)

v) Media Access Control-Ring Topology

3.2 INTRODUCTION

A network is defined as an interconnected collection of computers. Two computers are said to be interconnected, if they are capable of exchanging information. The term topology, in context of a communication network, refers to the way in which the end systems or stations are interconnected. Topology has been used in past to categories the local area networks because it determined the way in which the network operated. But today, we find same topology can be operated in many ways. Therefore network classification based on media access methods is more useful. In spite of this, a discussion on network topology is still useful to aid the later description of media access techniques.

3.3 LOCAL AREA NETWORK (LAN)

A networked of interconnected computers, which exists within a limited geographical area, such as a room, a building or a campus, is termed as a Local Area Network. Few characteristics of LAN are as below:

- Speed 4, 10, 16 up to 100MBPS
- Distance Few KMs (Typically 1.5KMs)
- Requires dedicated local wiring (Ethernet, Token Ring, FDDI, ATM)
- Shared access to medium

3.4 LAN TOPOLOGY

Common LAN topologies are Bus, Ring and Star, Network requirements of these topologies are:

- Flexible to accommodate
  - Changes in physical location of the stations
  - Increase in number of stations.
  - Increase in LAN coverage.
- Consistent with the media access method
- Minimum cost of physical media.

Bus Topology

In bus topology, a single transmission medium interconnects all the stations (Fig.3.1) All stations share this medium for transmission to any other station. Every stations listens to all the transmissions on the bus. Every transmission has source and destination address so that stations can pick the messages meant for them and identify their senders.

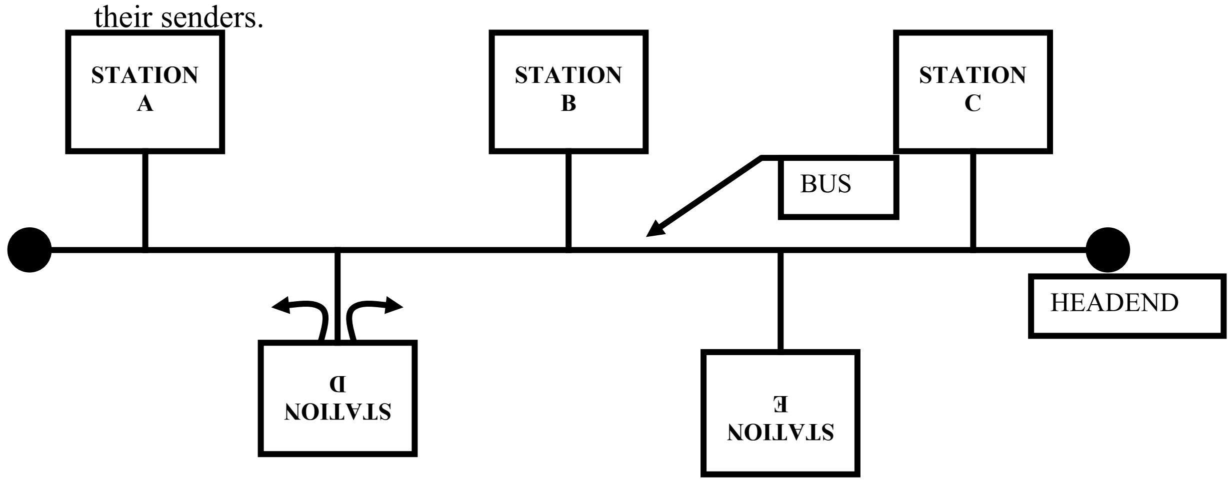

FIG. 3.1

1. Fig.3.1 shows a two-way bus. Each station injects its signals on the bus, which flow in both the directions. To avoid signal reflection at the ends of the bus, the bus is terminated by appropriate impedance (characteristic impedance) called head end. Note that signal flow is bi-directional, therefore amplifiers can not be used to compensate for bus attenuation. Repeaters which interconnect two buses are used for extending the physical coverage of the network (fig. 3.2). A repeater is transparent to rest of the system in the sense that it does not have buffer and interconnects the two sections to make them virtually one section.

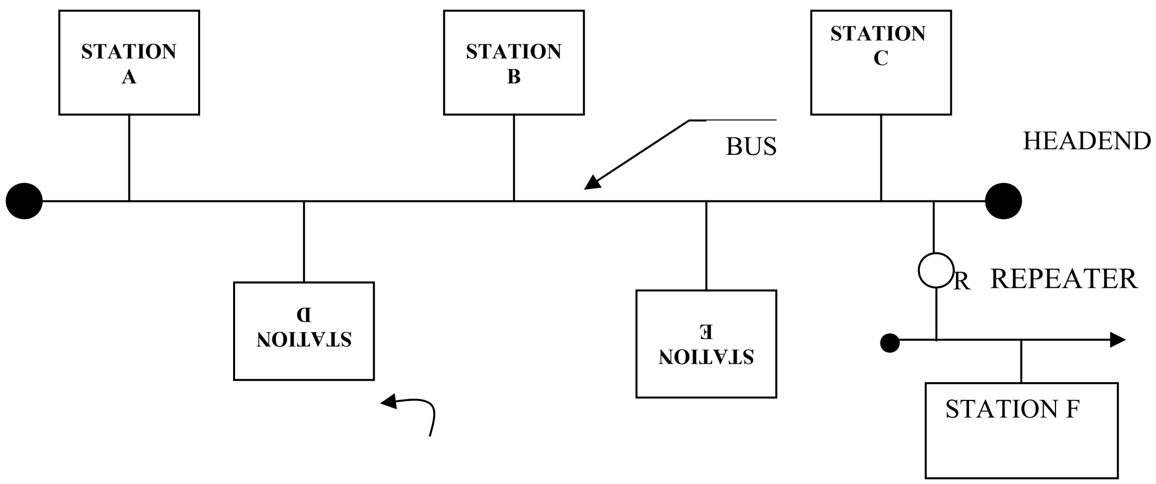

FIG. 3.2

If signals are amplified along the bus, the bus becomes unidirectional. Therefore two separate channels are required. Every station injects signal on one bus and listens to the other bus. At one end of the LAN, the buses are looped. These two channels can be provided on a signal bus also using frequency division multiplexing. In this case. the head-end contains a frequency translator. Stations transmit on one frequency and listen to other frequency.

Advantages of bus topology:

- Stations are connected to the bus using a passive tap.
- Least amount of media is used.
- Coverage can be increased by extending the bus using repeaters.
- New stations are easily added by tapping working bus.

Disadvantages of bus topology :

- Fault diagnostics is difficult
- Fault isolation is difficult
- Nodes must be intelligent

Ring Topology

A ring network consists of a number of transmission links joined together in form of a ring through repeaters called Ring interface Units (RIU). The transmission is usually unidirectional on the ring Thus each repeater receives the signals at its input and after regeneration, sends it to the repeater of the next station. If the frame belongs to the station, a copy of the incoming frame is retained. Each frame contains source and destination addresses. Fig. 3.3 shows a ring network.

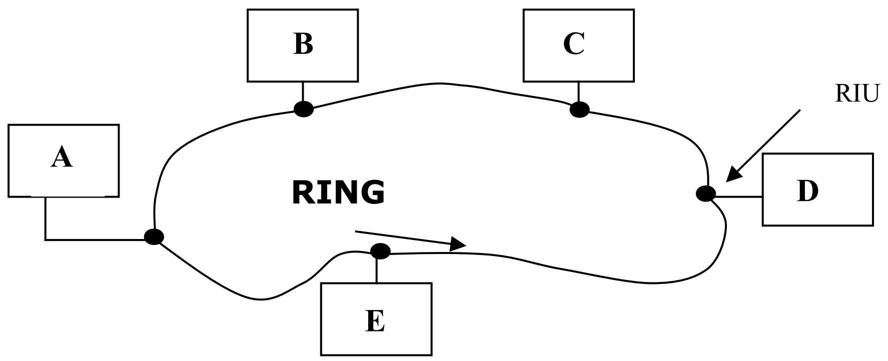

FIG. 3.3

Unlike a bus, signals on the ring never reach an end. They will keep circulating in the ring unless removed. This responsibility is usually given to the source because the destination may not be available. Possibility of source going down after transmitting a frame cannot be ruled out. Therefore a monitoring station is required to remove continuously circulating frames. Rings are not as flexible as bus because to add a station means breaking the ring and adding an RIU. Another possible problem can be an RIU may fail resulting in total network failure. A “Dead Man Relay” is usually provided to bypass a failed RIU. Wire centers are provided to improve flexibility of removing or adding a station and to isolate a faulty section To add a new station, cables are laid to the wire center. The bypass relays are also moved to the wire center. Wire centers can be connected together to increase geographic coverage of the network. A ring network does not economize on cables.

Advantages of Ring topology:

- Short cable length
- Suitable for optical fiber

Disadvantages of Ring:

- Node failure cause network failure
- Difficult to diagnose fault
- Network reconfiguration is difficult

Star Topology

A star network consists of dedicated links from the stations to the central controller (fig.3.4). Each interconnection supports two-way communication. The central controller acts as a switch to route the frames from source to the destination unlike ring or bus topologies where communication is in broadcast mode.

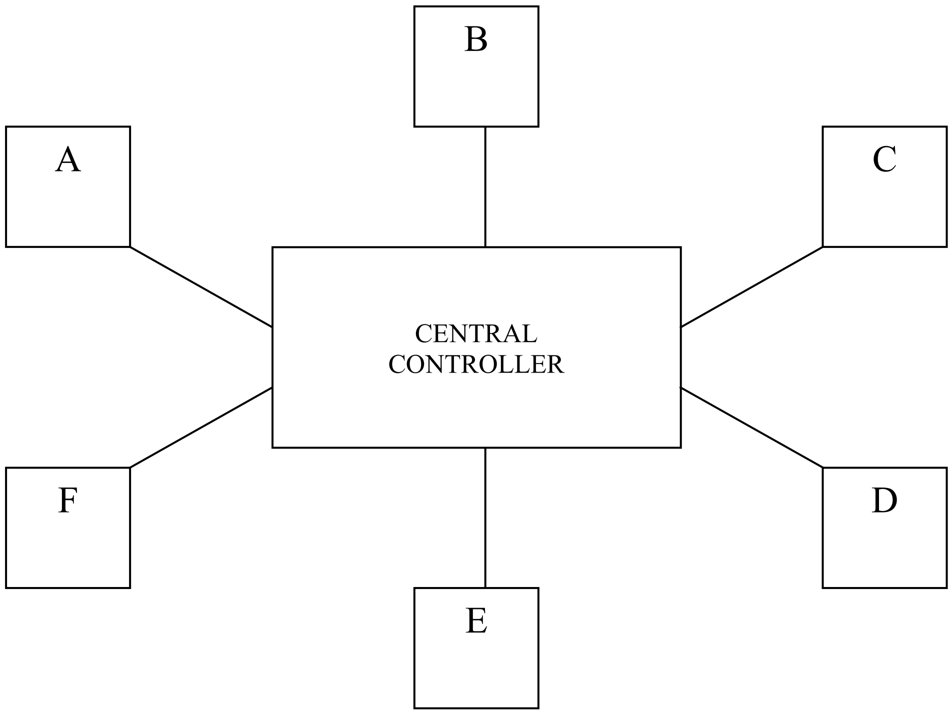

FIG. 3.4

Advantages of star topology:

- Control/fault diagnostics is centralized.
- Simple access protocols are employed.
- Ease of service
- One device per connection

Disadvantages of star topology:

While star topology is well understood and is based on prove technology (telephone network), its disadvantages are

- Single point of failure.
- No sharing of transmission

- Long cable lengths involved
- Difficult to expand
- Central node dependency

3.5 TRANSMISSION MEDIA FOR LAN

In a local area network, stations are interconnected using transmission media which can be a twisted pair, cable or a coaxial cable or even an optical fiber cable, Choice of transmission media depends on several factors. While data rate and cost are prime considerations, physical and electrical characteristics of the media need also to be taken into account because they determine ease of installation, noise immunity, geographical coverage etc. In this chapter, popular physical transmission media are discussed. They are twisted pair, base-band and broadband coaxial cables and optical fibers. Their physical construction, characteristics and applicability to various medium access methods are described.

3.5.1 Considerations for Choice of Transmission Media

The following features of the transmission media must be taken into consideration while choosing suitable media for local area networks.

Bandwidth

Bandwidth of the transmission media determines the maximum data rates which can be handled by the media Data rates are, of course, determined by the stations but the transmission medium should not become bottleneck in achieving the required data rate it must be kept in mind that bandwidth of transmission media is function of the length of the media e.g. it may be possible to achieve very high data rates on a low cost twisted pair but then maximum length of one transmission segment is limited to not more than a few meters.

Connectivity

Some transmission media are suitable for broadcast mode of operation and point to multi-point links, while others are better suited for point to point links. For example, the present status of technology, Optical fiber is suited for point to point links only.

Geographic Coverage

In a LAN operating in broadcast mode on a bus, the electrical signals should reach from one end to the other without degradation in quality of the signals below the required limits. Attenuation and group delay characteristics of the medium determine overall distortion in the signals. These characteristics are function of distance and therefore determine the geographic coverage of the LAN. Propagation time, which is also dependent on the media characteristics, is an important consideration in that access mechanism where propagation delay determines the length of one segment of the media.

Noise immunity

Ideally the transmission media chosen for LAN should be free from interference from outside sources practically it is not possible. Degree of immunity to interference varies from media to media, Susceptibility to interference is because LAN cabling is usually done in the same ducts which carry power cables also. Degree of noise immunity required depends on environment where a LAN is installed.

Security

In some of the LAN topologies and access methods it is very easy to tap on the LAN & pick up the messages without generating any alarm. For considerations of data security, the transmission medium is to be so chosen that it may not be easily tapped.

Cost.

At present state of technology, cost of different media are different and are changing continuously. Metallic media is becoming costlier and optical fiber costs are going down. Cost of media is also related to the cost of equipment associated with the media. Therefore an overall view of cost structure is more important than media alone

In most of the instances, the LAN vendors specify the medium for which their products are designed. A look into the characteristics of media do help the user in becoming aware of the limitations of the transmission medium being supplied by the vendor. A comparison of various transmission media is given in Tables 1, 2 and 3 the end.

3.5.2 Twisted Pair Cable

By far the most common transmission media is twisted pair. It is also the most underestimated media. Although it is extensively used for voice communication, it can handle frequencies much higher than voice band.

Types of Twisted Pair

A twisted pair consists of two insulated wires twisted together in a spiral form (Fig. 3.5a). Twisting reduces cross talk and interference problems. More than one pair can be bundled together in form of a cable (Fig. 3.5b). A twisted pair can also have a metallic braid as a shield (fig. 3.5c) to protect against noise.

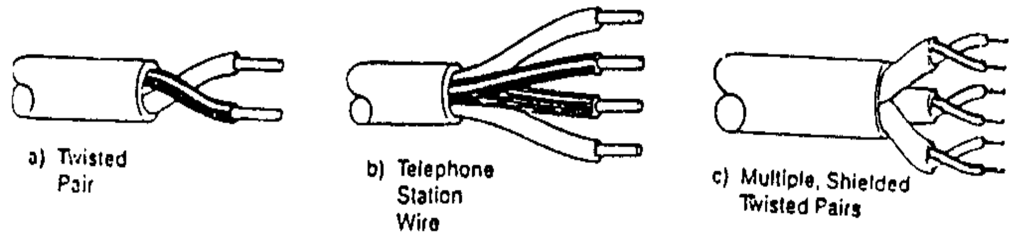

FIG. 3.5

Twisted pair is used for point to point, and point to multi-point applications. But as multi-point media, it supports fewer stations and over smaller distances than coaxial cable because of signal impairment. Tapping into twisted pair for additional stations is not so straight forward without disturbing other users or without changing transmission characteristics of the media. Cost wise twisted pair is less expensive than coaxial cable or optical fiber.

3.5.3 Coaxial Cable

Coaxial cable is widely used as transmission medium in local area networks. It consists of a central conductor, which can be solid or stranded, and an outer surrounding conductor (Fig. 3.6). The outer conductor can be solid or a braid. A solid dielectric material separates the two conductors. If no dielectric material is used spacers are provided to hold the conductors in place. Coaxial cable has very low loss, high bandwidth and very low susceptibility to external noise and cross talk.

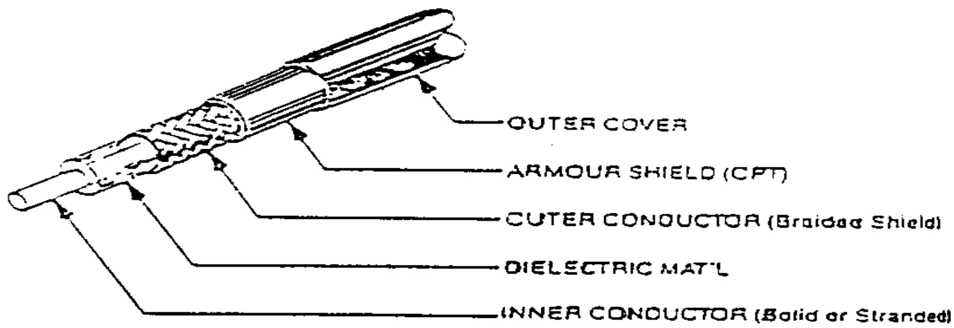

FIG. 3.6

50 Ohm & 75 Ohm CATV coaxial cables are popular in local area networks. These impedance's refer to characteristic impedance of the cable 50Ohm cable is called base band cable because digital signals are transmitted without any modulation. The outer conductor is metallic braid in 50Ohm cable. Digital signals up to 10Mbps can easily be transmitted on base-band cable.75 Ohm cable is broadband cable as it has bandwidth around 400MHz. It has solid outer conductor. Digital signals are transmitted on this cable on modulated carrier. Unlike base-band, broadband cable is unidirectional. Bi-directional connectivity is achieved by dividing the frequency band into inbound and outbound frequency bands.

For a 400MHz cable, the typical frequencies are 5-174MHz (inbound carrier) and 232-400MHz (outbound carrier). Frequency translation takes place at the head-end. A re-modulator can also be used at the head-end. Re-modulator demodulates the inbound carrier, regenerates the digital signal and then re-modulates it at the outbound carrier frequency. Coaxial cables can be used both for point to point and point to multipoint applications. When used as a bus, 50Ohm cable can support of order of 100 devices per segment, the maximum length of a segment being 500 meters. For distances more than five hundred meters, repeaters are required. 75Ohm broadband cable can support about 1000 taps over a length of about 4 km. When used as bus, the coaxial cable can be easily tapped to add a new station. Fig. 3.7 shows a coaxial cable tap.

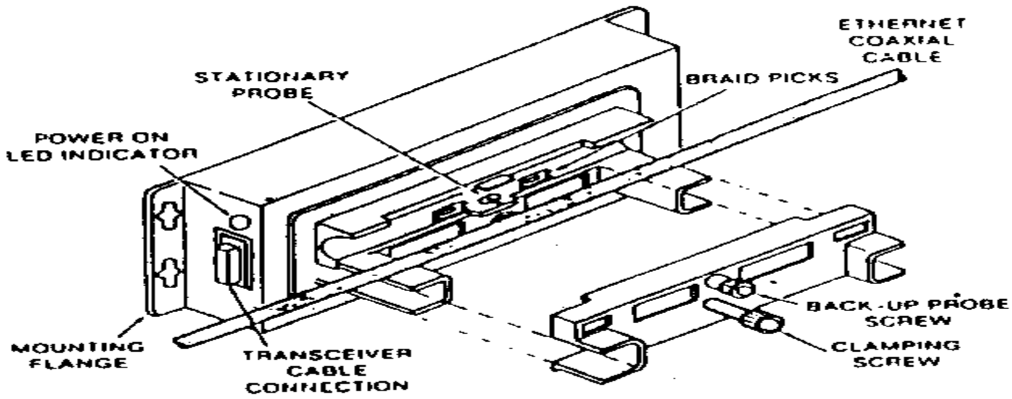

FIG. 3.7

Geographic coverage of the coaxial cable is better than twisted pair but it depends on end to end propagation delay which can be afforded on the network. Cost wise coaxial cable is costlier that twisted pair but overall cost of installed cable is marginally different due to significant cable installation cost in either case.

3.5.4 Optical Fiber Cable

With optical fibers it is possible to realize very high data rates (~ gigabits) over much larger distances compared to about a few kilometers of coaxial cables. Use of optical fiber in local area networks has not been widespread due to its high cost, special installation practices, non-availability of low loss components. But with the rapid developments being made in this field, optical fibers have a very promising future.

Optical fire consists of an inner glass core surrounded by a cladding also of glass but having higher refractive index (Fig. 3.8). Transmission of digital signals is in form of light (wavelength 850-1600nmts) signal, which is trapped in the core due to total internal reflection at the core/cladding interface. Light is launched into the fiber using a light source (LED or LASER) and is detected at the other end using a photo detector.

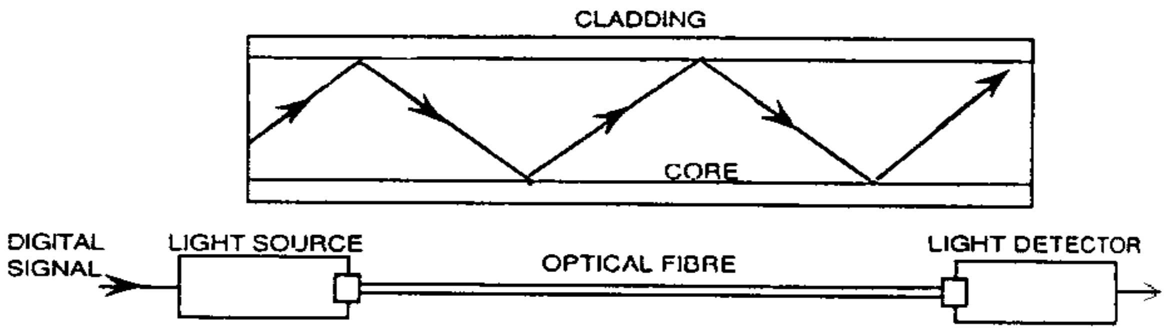

FIG. 3.8

Fibers are of three types

- Step index, multi-made.
- Step index, mono-mode.
- Graded index fiber.

Pulse transmission through an multimode step index fiber suffers from pulse spreading called modal dispersion which restricts the data rate over large distances. Graded index and mono-mode fibers overcome this limitation. Optical fiber systems distinguish themselves from coaxial and twisted pair cable systems due to their following basic characteristics.

- Greater bandwidth
- Smaller size and lighter
- Greater repeater spacing due to low loss
- High immunity to electromagnetic interference
- Secure communication.

3.6 TOPOLOGY & MEDIA PREFERENCES

The choices of transmission media and topology are not independent. As discussed above some media are more suitable for point-to-point transmission rather than point to multipoint. Other considerations for choice of media for a topology would include under utilization of media capabilities and cost considerations.

Table - 1 shows preferred combinations by the LAN industry

MEDIA	TOPOLOGY		
	BUS	RING	STAR
Twisted Pair	X	X	X
Base band coaxial	X	X	
Broadband coaxial	X		
Optical Fiber		X	

Representative features of ring and bus topologies for the various media are given in Tables 2 & 3

Table – 2 Characteristics of Media for Ring Topology

MEDIA	DATA RATE (MBPS)	REPEATER SPACING (KM)	NUMBER OF REPEATERS
Twisted Pair (Unshielded)	4	0.1	72
Twisted Pair (Shielded)	16	0.3	250
Base Band Coaxial Cable	16	1.0	250
Optical Fiber	100	2.0	240

Table – 3 Characteristics of Media for Bus Topology

MEDIA	DATA RATE (MBPS)	RANGE (KM)	NUMBER OF TAPS
Twisted Pair (Unshielded)	1	2	10s
Twisted Pair (Shielded)	10	3	100s
Base band Coaxial Cable	20 per channel	30	1000s

3.7 MEDIA ACCESS CONTROL

The physical topology of local area networks can take shape of a bus or ring or a star but the network attributes in terms of delay, throughput, expandability etc. are determined by the mechanisms utilized for sharing the use of physical interconnecting media. There are many methods sharing the media and they are, in general, called Media Access Control methods. These methods can be categorized as :

- Access Centrally Controlled
- Distributed Access Control

In the former access to the media is controlled by a central controller. There are several ways in which the media is shared, e.g. Polling, demand assigned time division or frequency division multiple access, etc. But in local area networks, distributed access control methods are more common and are described in the following sections.

3.7.1 Distributed Access Control

As name implies, there is no single controller for the shared media. A disciplines built up among the various stations (station refers to a LAN terminal/host/any other device) of the local area network so that a fair opportunity is given to each station to transmit its data which is in the form of frames. The basic advantage of distributed control over centrally controlled methods is that there is no single point of network failure. Distributed access control methods are available both for bus and ring topologies.

3.7.2 Media Access Control – Bus Topology

An interconnecting bus can be thought of as single data transmission channel to which all the stations of the network are connected. A bus can be a twisted pair cable, a coaxial cable or even an optical fiber cable.

The bus operates in broadcast mode, i.e. all the stations are always listening to all the transmissions on the bus. Access control mechanisms are so designed that transmissions from different stations do not intermingle and all the stations get fair chance to transmit. There are two techniques which dominate the present day market : Token passing and CSMA/CD. These two techniques are described below. CSMA/CD is a contention access technique and covered under this general heading.

3.7.3 Token Passing

In token passing method, the stations connected on a bus are arranged in a logical ring i.e. the addresses of the stations are assigned a logical sequence with the last number of the sequence followed by the first (Fig. 3.9). Each station knows identity of the stations proceeding and following it.

Access to the interconnecting bus is regulated by a control frame known as token. At a time only one station which holds the token has right to transmit its frame on the bus. The operation of token passing bus is as follows:

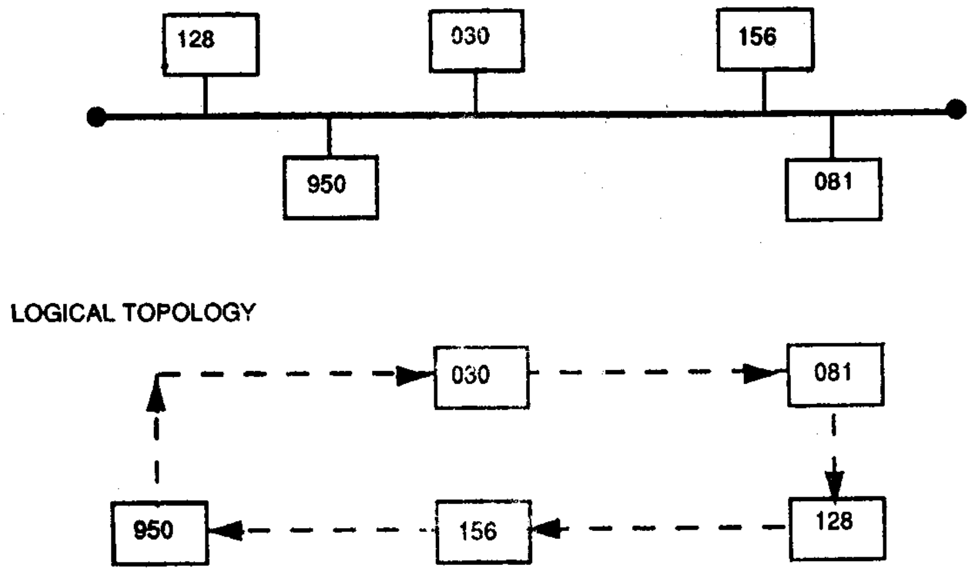

FIG. 3.9

On the bus all the stations operate in broadcast mode so that every station can hear every transmission. When a station detects a token on the bus with its address, it transmits its data frame(s) each containing the source and destination addresses (Fig.3.10). In the end, it transmits the token with address of the next station in the logical ring. Thus, in one cycle each station gets an opportunity to transmit. It is possible for a station to have more than one turn in a cycle (e.g. by giving it more than one address).

To maintain continuity of communication, it is necessary that when turn comes each station transmits the token frame even if there is no data to send. The transmission sequence can get disrupted if a station is down. To account for such eventuality, a timer is provided. Station holding the token must release the token before time out else next station takes over and deletes the station from the logical ring for future transmissions.

PREAMBLE	SD	FC	DA	SA	DATA	FCS	ED

PREAMBLE	-	BIT SYNCHRONISATION	SA	-	SOURCE ADDRESS
SD	-	FRAME START DELIMITER	DATA	-	DATA FIELD
FC	-	FRAME CONTROL (TYPE)	FCS	-	FRME CHK SEQUENCE
DA	-	DESTINATION ADDRESS	ED	-	END DELIMITER

FIG. 3.10

The frame format shown above is as per IEEE 802.4 standard. The "FC" field indicates whether it is a data frame or token. Delay in completing data transfer depends on number of stations, propagation and transmission times and traffic. Token passing LANs operate at data rates 1 Mbps to 10 Mbps.

3.7.4 Contention Access

CSMA/CD is a contention access method in which there is no scheduled time or sequence for stations to transmit on the medium. They compete for the use of the medium. It is, therefore, quite likely that more than one station will transmit simultaneously and the data frames will "collide". There are rules and mechanisms to reduce the likelihood of these collisions. These methods in general are called contention access methods for the way in which access to the medium is gained. Origination of contention access techniques is Aloha Radio network which used a random access mechanism now called Pure Aloha. We shall, therefore, first look at the Aloha access mechanism.

Pure Aloha

This access mechanism was originally used in Aloha Radio Network which provides a single radio channel for access by number of stations to a central computer. The scheme is as under :

- A station can transmit whenever it wants. There is no pre-assigned time or sequence. If a station starts to transmit when another transmission is already in progress, collisions will occur. but there will be some instances when transmissions will reach the destination without any collision.

- A mechanism to detect collision is established (e.g. acknowledgement). Collision is assumed to have occurred and the message is retransmitted if the acknowledgement is not received within specified time (twice the propagation time plus processing time).

The link utilization of Pure Aloha access method is somewhat modest, mere 18%.

The reason for poor efficiency is large wasted time when a collision occur (Fig. 3.11). Note that even though there may have been only a few bits of overlap, the whole of the two packets time is wasted due to the collision.

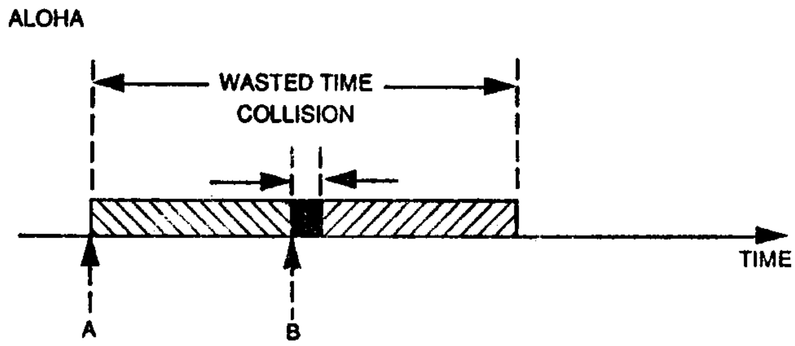

FIG. 3.11

Provided that there is relatively little traffic on the network and the packet size is fairly small, then this technique is reasonably good.

Slotted Aloha

Wasted time due to collisions can be reduced if all the transmissions are synchronized. The channel time is divided into time slots and the stations are allowed to transmit at specific instants of time so that all transmissions arrive aligned with the time slot boundaries (Fig. 3.12).

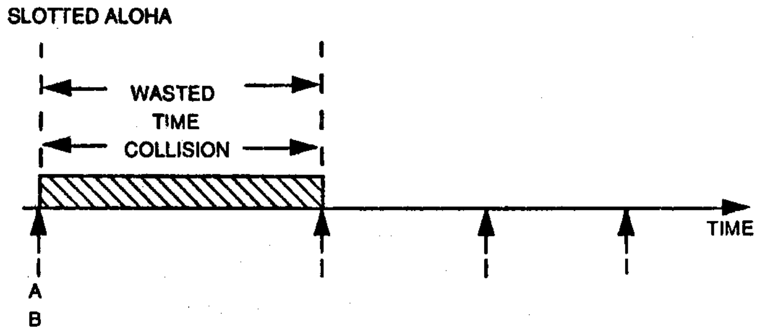

FIG. 3.12

3.7.5 Carrier Sense Multiple Access (CSMA)

In Aloha channel discussed above, possibility of collision can be reduced if some discipline is built into totally random access mechanism. If a station senses the carrier (we are using the term carrier, despite the fact that most of the baseband local area networks do not use carrier to transmit data) before starting its own transmission, a collision can be avoided. CSMA as the name suggests, is based on this principle. Consider a situation where frame transmission time is much more than propagation time, i.e. once a transmission starts, it is soon heard by all. If a station has a frame to send, it listens to the channel, and if it is quite, it starts to transmit. It will be soon heard by other stations, which defer their transmission on sensing the carrier. Contention for the channel can take place only during the first few bits of the frame when the first bit is still in transit. Once, the first bit is heard by every terminal, there cannot be a collision. To account for possibility of collision during first few bits, acknowledgement is transmitted by the recipient. In CSMA, an algorithm is needed to specify when a station can transmit once the channel is found busy. There are several ways in which the waiting frames can be transmitted (Fig. 3.13).

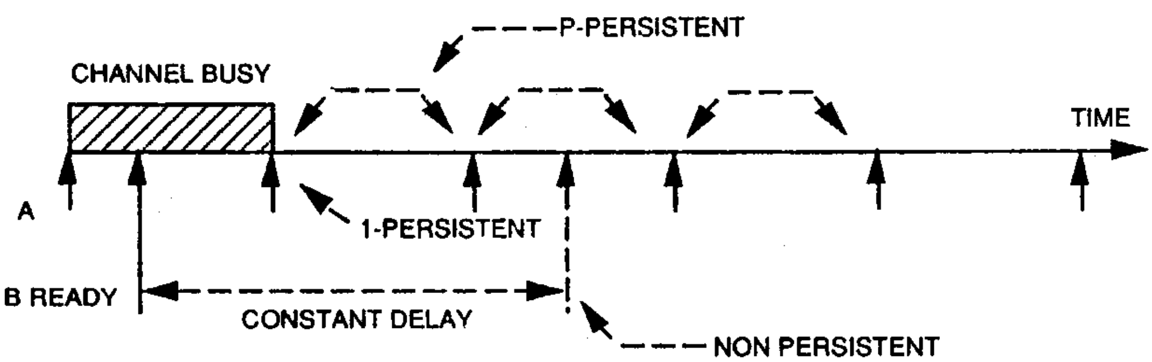

FIG. 3.13

Non-Persistent CSMA

In this scheme, when a station having a frame to send finds that channel is busy, it backs off and waits for a fixed interval of time. Then it again senses the channel for transmission of its frame. If the channel is free, it transmits. The back off delay is determined by transition time, propagation time and other system parameters. There is likelihood of some wasted idle time when channel is not in use by any station.

1-Persistent CSMA

In this scheme, stations wishing to transmit, monitor the channel continuously until the channel is idle and then transmit immediately. The problems with this strategy is that if two stations are waiting to transmit, then they will collide-always, and require retransmission.

P-Persistent CSMA

To reduce the probability of collision in 1-Persistent CSMA, not all the waiting stations are allowed to transmit immediately after the channel is idle. A waiting station transmits with probability p if the channel is idle. For example, if 10 stations are waiting with $p = 0.1$, on average only one station will transmit and the rest nine will wait. Optimized P-persistent CSMA is about 82% efficient from link utilization point of view while 1-persistent CSMA achieves about 53% efficiency.

CSMA/CD

One of the most commonly used multiple access technique in the current local area networks is CSMA/CD where CD stands for Collision Detection. One limitation of CSMA techniques discussed above is that even after a collision has occurred, the stations continue transmissions till all the bits of the frames are over. This result in unnecessary wastage of channel time. If the stations listen to the channel while they are transmitting, a collision can be detected as soon as it occurs and further transmission can be abandoned thus saving the channel time. This scheme is known as CSMA/CD and as illustrated in Fig. 3.14. Naturally for the technique to work properly, each station should not attempt to transmit again immediately after a collision has been detected. Otherwise the same frames will collide again. Usually the stations are given a random back off delay for retry. If collision repeats, back off delay is increased. In Ethernet back off delay is doubled on each repetition of collision. In this way, the network adapts itself to the loading conditions. By careful design, it is possible to achieve efficiencies more than 90% using CSMA/CD.

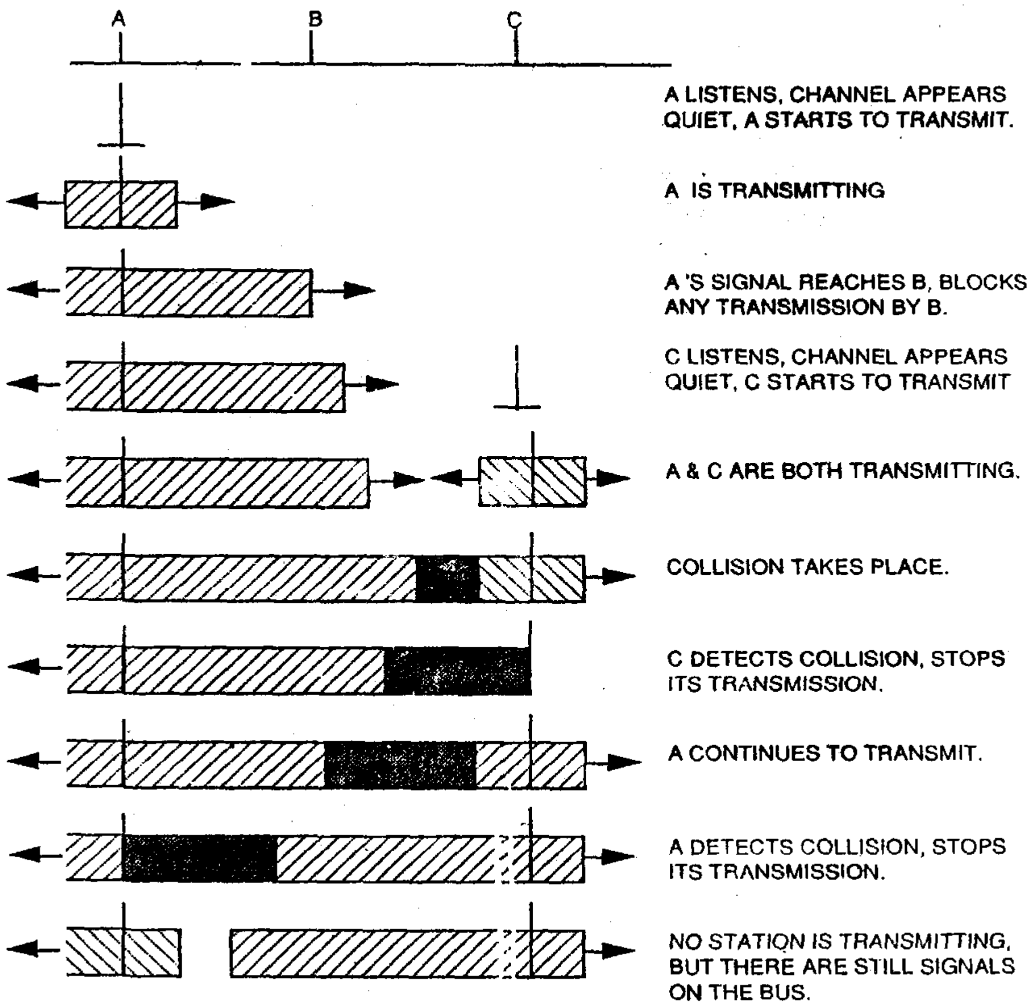

FIG. 3.14

Frame format as per IEEE 802.3 standard is shown in Fig. 3.15. The format is very close to that of Ethernet. The individual fields are as given below :

- Preamble (PR) - used for bit synchronization
- Start Frame Delimiter - identifies start of the frame (SFD)
- Destination Address - specifies the destination (DA)
- Source Address (SA) - identifies the source
- Length (L) - specifies number of data bytes
- Data - contains data bytes
- Pad - contains additional bytes to make up the frame of required size.
- Frame Check Sequence - (FCS)

PR	SFD	DA	SA	L	DATA	PAD	FCS

PR	:	PREAMBLE	SA	:	SOURCE ADDRESS
SFD	:	START FRAME DELIMITER	L	:	LENGTH
DA	:	DESTINATION ADDRESS	FCS	:	FRAME CHK SEQUENCE

FIG. 3.15

3.7.6 Media Access Control-Ring Topology

Media access control methods for ring topology are substantially different from those used in bus topology. While bus operates in broadcast mode, a ring is formed of number of point-to-point links and transmission of bits is unidirectional.

The data frames are always passed from one station to the next, after having been regenerated at the station. Unlike a bus system where the frame disappear naturally at the two ends of the bus, in a ring, the frame finally comes back to the source and it has to be removed from the ring by the station. The destination node is not made responsible for this, since there is no guarantee that it will be available and working when the frame arrives.

Another very important feature of media access in ring topology is that the stations which are down have to be removed from the ring else there will be total network failure. This is so because every station also acts as a repeater. The commonly used ring access techniques are :

- Token Passing
- Register Insertion

Out of the above, token passing is more popular.

Token Passing On A Ring

A token passing ring consists of number of point-to-point links interconnecting adjacent stations (Fig. 3.16). Each station is connected to the ring through a Ring Interface Unit (RIU). Each RIU regenerates the data frames it receives and sends them onto the next link. RIU also makes available the incoming frame to the local station which accepts the frame if it is addressed to it.

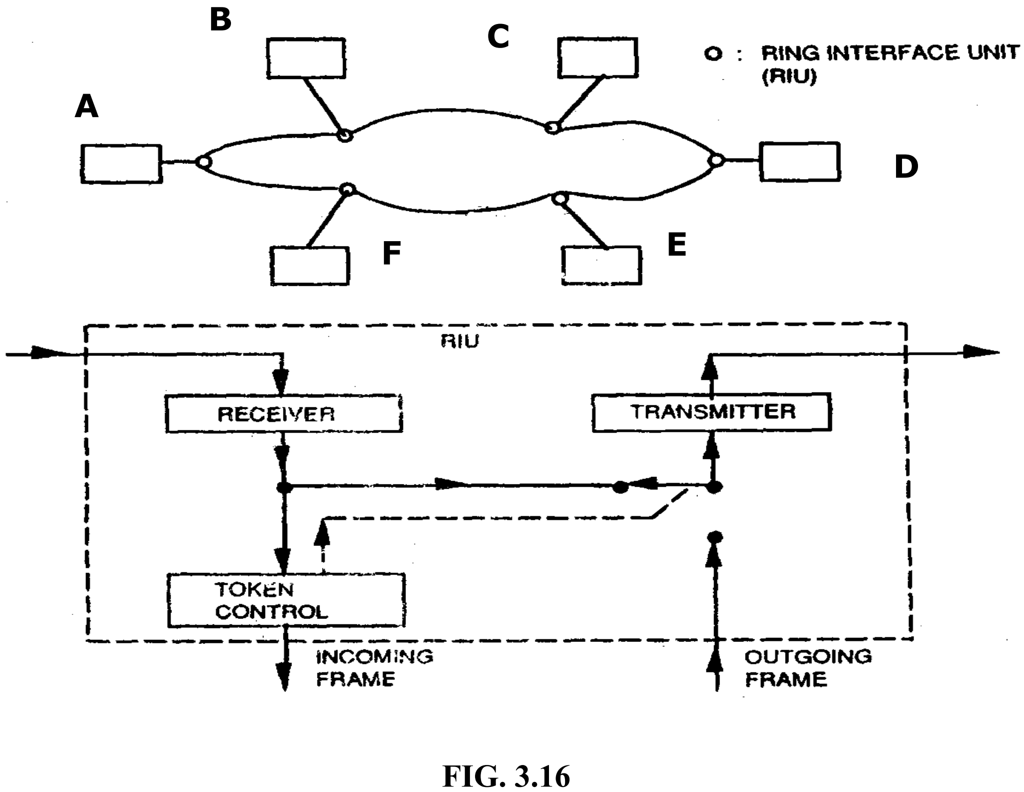

FIG. 3.16

Access to the medium is controlled by use of a token as in token bus. The token, i.e. permission to transmit is passed from station to station around the ring. Frame formats standardized in IEEE 802.5 are shown in Fig.3.17. Fourth bit of the "AC" field is called token bit. A station which has a frame to send, waits for the token bit. If the token bit indicates it is a token frame the station seizes the token by changing the token bit. This change transforms the "AC" field to that of a data frame. The station then appends and transmits rest of the fields which make up a data frame.

TOKEN FRAME

SD	**AC**	**ED**

DATA FRAME

SD	**AC**	**FC**	**DA**	**SA**	**DATA**	**FCS**	**ED**	**FS**

SD	**START DELIMITER**
DA	**DESTINATION ADDRESS**
AC	**ACCESS CONTROL**
SA	**SOURCE ADDRESS**
ED	**END DELIMITER**
FCS	**FRAME CHECK SEQUENCE**
FC	**FRAME CONTROL**
FS	**FRAME STATUS**

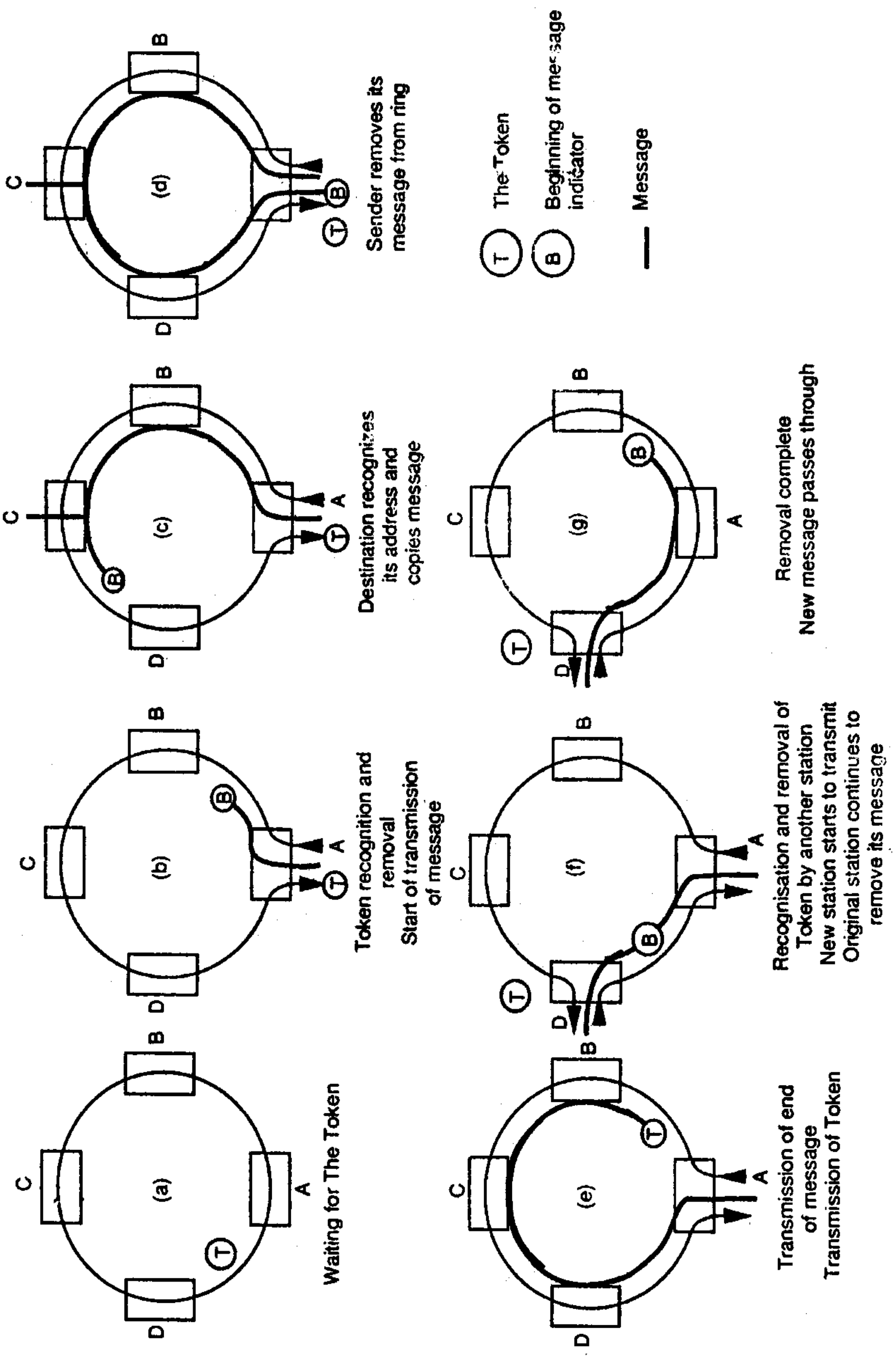

FIG. 3.17

While in possession of the token, the station may transmit its data frames but eventually must release the token by transmitting the token frame. The data frame moves along the ring till it arrives at the destination indicated in the "DA" field. The destination station copies the frame and in the last field "FS" indicates frame copied

Fig. 3.18

status. When the frame eventually reaches the originating section, it is removed from the ring. Fig. 3.18 shows the sequence of events when station "A" sends a frame to station "C" and then the token is picked up by station "D". Note that size of the ring in terms of bits is less than the size of the frame and, therefore, frame comes back to the originating station after traversing the ring even before it has been completely transmitted.

3.7.7 Register Insertion Ring

In register insertion technique, a shift register is placed in parallel to the ring at each station. The shift register can be switched in/out of ring as shown in Fig. 3.19. Normally the register is switched out of the ring. When a station has a frame to send, it places it in the register and waits for a gap in the data stream being transmitted on the ring. When it finds a gap, it inserts the shift register in the ring. The frame stored in the register is sent bit by bit on the ring at outgoing end of the shift register. The incoming data is read into the shift register from the other end. The register remains in the ring till the frame comes back. As soon as the returned frame gets stored in the shift register, the register is switched out of the ring so that the frame is removed from the ring.

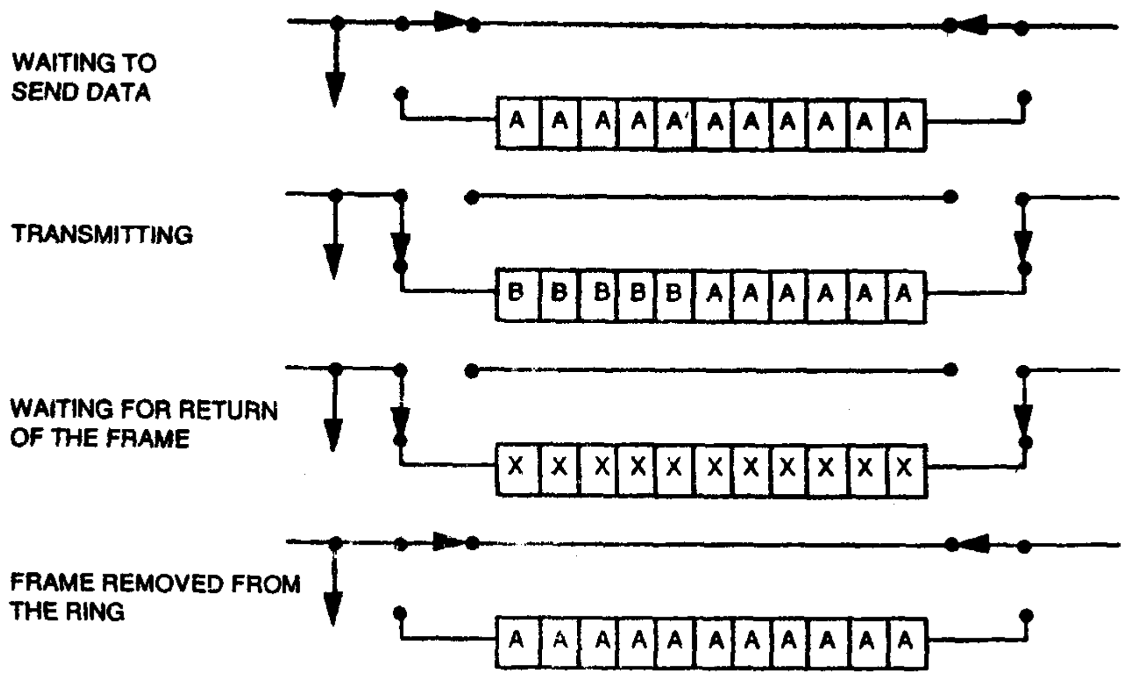

FIG. 3.19

The above figure shows the configuration in simplified form. In real implementation, additional registers are required. Also, note that in effect length of the ring increases every time a station inserts its register in the ring. Thus, the ring is able to accommodate more bits. Time to transport a frame from source to the destination also increases as number of registers in the ring increases.

3.7.8 Comparison Of Access Methods

Out of the access methods discussed above, the three most important are CSMA/CD, Token Passing on Bus, Token Passing on Ring. Some channels on their qualitative comparison are given below :

CSMA/CD

- Totally decentralized control.
- No guaranteed maximum waiting time for access.
- Short delay for light traffic.

Token Passing on Bus

- Guaranteed maximum waiting time for access.
- Easily expanded.
- Moderate overhead of token.
- Potential for high utilization of media.

Token Passing on Ring

- Guaranteed maximum waiting time for access
- Low overhead of token passing.
- Easily expanded.