IEEE Standards

IEEE stands for Institute of Electrical and Electronics Engineers. It is a professional association with a nonprofit organization with its headquarter in New York in the United States of America. It is composed of engineers, scientists, allied professionals, advancing innovation and technological excellence for the benefit of humanity. IEEE mainly focuses on the areas of Electrical Engineering, Electronics & Communication Engineering, Computer Engineering, and Information Technology.

History

On January 1, 1963, IEEE merged with two institutions, the AIEE (American Institute of Electrical Engineers) was founded in 1884 and the IRE (Institute of Radio Engineers) was founded in 1912 to form the Institute of Electrical and Electronics Engineers (IEEE). In the starting, it had 150, 000 members and 140, 000 from the United States.

Characteristics

1. **Compatibility:** Able to achieve performance very similar to that currently offered by Ethernet, meeting the current traffic demands.
2. **Technical societies:** There are various technical areas addressed by IEEE's 39 societies and each one focused on a certain knowledge area.
3. **Media:** Each of the IEEE standards specifies the medium through which signals are traveled in a network. Like Twisted Pair cable, coaxial cable, etc.
4. **Speed**: The IEEE standard defines the maximum speed through which data can be transferred. Usually, the data transfer speed is in Mbps, but in some fast systems, it can go up to Gbps.
5. **Access Method**: IEEE standard defines the method through which a network system can access a transmission channel to send/receive the data.
6. **Topology:** Topology used by the network can be implemented using the IEEE LAN standard.

List of IEEE standards

Here is a list of IEEE standards used in computer networking, also known as IEEE 802 standards, the list is as follows:

IEEE Standard	Description
IEEE 802	For LAN/MAN networks
IEEE 802.1	Standards for LAN/MAN management and bridging and remote media access control bridging.
IEEE 802.2	For Logical Link Control connectivity.
IEEE 802.3	Standards for CSMA/CD.

IEEE Standard	Description
IEEE 802.4	Standards for the token passing bus access.
IEEE 802.5	For communication between LAN and MAN, and standard for token ring access.
IEEE 802.6	For exchanging information between systems
IEEE 802.7	For broadband LAN cable
IEEE 802.8	For Fiber-optic connection
IEEE 802.9	For integrated services, like voice-over video, etc.
IEEE 802.10	For security implementation in LAN/MAN
IEEE 802.11	For WiFi or Wireless Networking
IEEE 802.12	For demand Priority Access Method
IEEE 802.14	For Cable TV broadband communications
IEEE 802.15.2	For Bluetooth and Wifi co-existence mechanism
IEEE 802.15.4	For Wireless Sensors or Control Systems
IEEE 802.15.6	For Wireless Body Area Network, like Bluetooth low energy
IEEE 802.16	For Wireless Network connectivity, like WiMax
IEEE 802. 24	To facilitate collaboration and coordination among all IEEE 802 standards

Advantages

1. The data communication system is faster than the speed of transportation.
2. Multi-path propagation increases the transmission rate and reduces error incidence.

3. Manually fix the modulation used by the transmission.
4. Developing standards for the computer and electronic industry.
5. It is a non-profit professional association and works for the benefit of Humanity.

Disadvantages

1. It requires periodic maintenance.
2. Network security needs to stay secure.
3. It has unauthorized use.

FDDI

FDDI stands for **Fiber Distributed Data Interface**. It is a set of ANSI and ISO guidelines for information transmission on fiber-optic lines in Local Area Network (LAN) that can expand in run upto 200 km (124 miles). The FDDI convention is based on the **token ring protocol.**
In expansion to being expansive geographically, an FDDI neighborhood region arranges can support thousands of clients. FDDI is habitually utilized on the spine for a Wide Area Network(WAN).

An FDDI network contains **two token rings,** one for possible backup in case the essential ring falls flat. The primary ring offers up to 100 Mbps capacity. In case the secondary ring isn't required for backup, it can also carry information, amplifying capacity to 200 Mbps. The single ring can amplify the most extreme remove; a double ring can expand 100 km (62 miles).

Characteristics of FDDI

- FDDI gives 100 Mbps of information throughput.
- FDDI incorporates two interfaces.
- It is utilized to associate the equipment to the ring over long distances.
- FDDI could be a LAN with Station Management.
- Allows all stations to have broken even with the sum of time to transmit information.
- FDDI defines two classes of traffic viz. synchronous and asynchronous.

Advantages of FDDI

- Fiber optic cables transmit signals over more noteworthy separations of approximately 200 km.
- It is conceivable to supply the need to the work stations associated within the chain. Consequently, based on the prerequisite a few stations are bypassed to supply speedier benefit to the rest.
- FDDI employments different tokens to make strides organize speed.
- It offers a higher transmission capacity (up to 250 Gbps). Thus, it can handle information rates up to 100 Mbps.
- It offers tall security because it is troublesome to spy on the fiber-optic link.
- Fiber optic cable does not break as effectively as other sorts of cables.

Disadvantages of FDDI

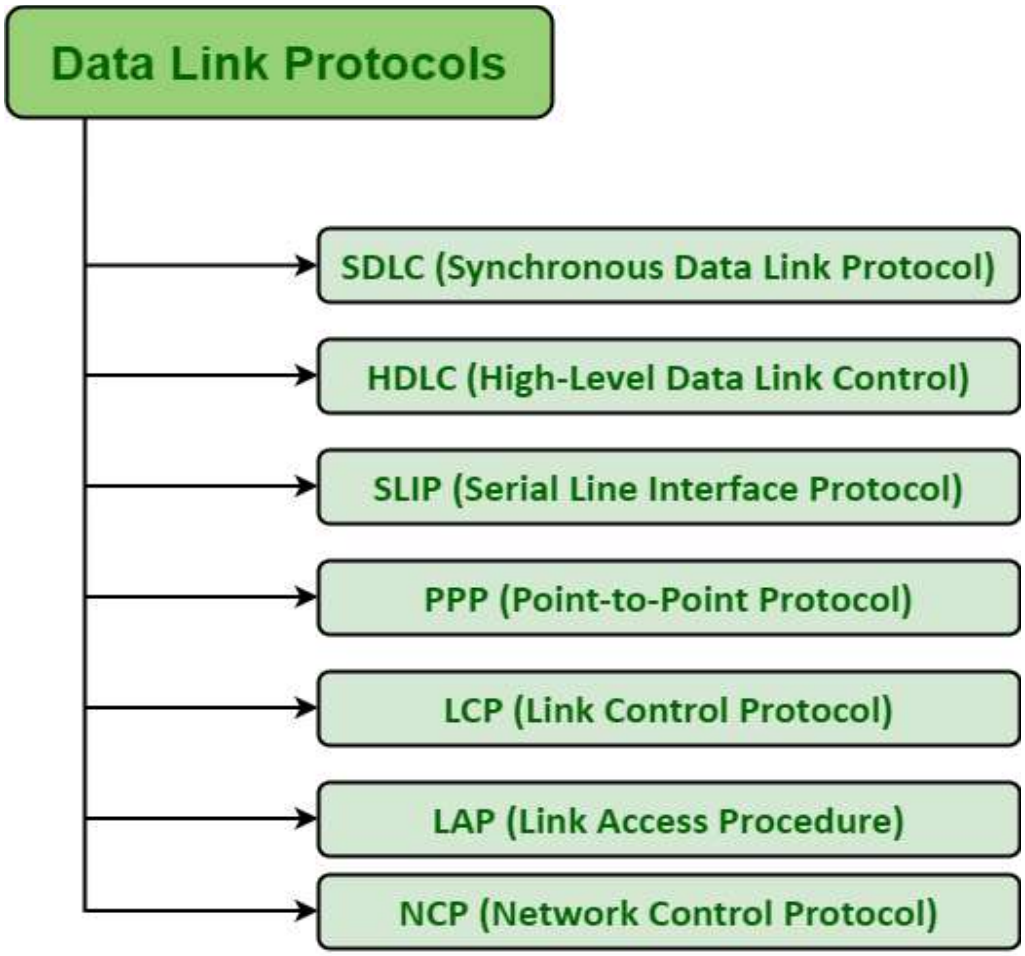
- FDDI is complex. Thus establishment and support require an incredible bargain of expertise.
- FDDI is expensive. Typically since fiber optic cable, connectors and concentrators are exceptionally costly.

Data Link Layer Protocols

- Data Link Layer protocols are generally responsible to simply ensure and confirm that the bits and bytes that are received are identical to the bits and bytes being transferred. It is basically a set of specifications that are used for implementation of data link layer just above the physical layer of the Open System Interconnections (OSI) Model.

Some Common Data Link Protocols:

There are various data link protocols that are required for Wide Area Network (WAN) and modem connections. Logical Link Control (LLC) is a data link protocol of Local Area Network (LAN). Some of data link protocols are given below :



1. **Synchronous Data Link Protocol (SDLC) –**

   SDLC is basically a communication protocol of computer. It usually supports multipoint links even error recovery or error correction also. It is usually used to carry SNA (Systems Network Architecture) traffic and is present precursor to HDLC. It is also designed and developed by IBM in 1975. It is also used to connect all of the remote devices to mainframe computers at central locations may be in point-to-point (one-to-one) or point-to-multipoint (one-to-many) connections. It is also used to make sure that the data units should arrive correctly and with right flow from one network point to next network point.

2. **High-Level Data Link Protocol (HDLC)** –

   HDLC is basically a protocol that is now assumed to be an umbrella under which many Wide Area protocols sit. It is also adopted as a part of X.25 network. It was originally created and developed by ISO in 1979. This protocol is generally based on SDLC. It also provides best-effort unreliable service and also reliable service. HDLC is a bit-oriented protocol that is applicable for point-to-point and multipoint communications both.

3. **Serial Line Interface Protocol (SLIP) –**

   SLIP is generally an older protocol that is just used to add a framing byte at end of IP packet. It is basically a data link control facility that is required for transferring IP packets usually among Internet Service Providers (ISP) and a home user over a dial-up link. It is an encapsulation of the TCP/IP especially designed to work with over serial ports and several router connections simply for communication. It is some limitations like it does not provide mechanisms such as error correction or error detection.

4. **Point to Point Protocol (PPP) –**

   PPP is a protocol that is basically used to provide same functionality as SLIP. It is most robust protocol that is used to transport other types of packets also along with IP Packets. It can also be required for dial-up and leased router-router lines. It basically provides framing method to describe frames. It is a character-oriented protocol that is also used for error detection. It is also used to provides two protocols i.e. NCP and LCP. LCP is used for bringing lines up, negotiation of options, bringing them down whereas NCP is used for negotiating network-layer protocols. It is required for same serial interfaces like that of HDLC.

5. **Link Control Protocol (LCP)**

   It was originally developed and created by IEEE 802.2. It is also used to provide HDLC style services on LAN (Local Area Network). LCP is basically a PPP protocol that is used for establishing, configuring, testing, maintenance, and ending or terminating links for transmission of data frames.

6. **Link Access Procedure (LAP) –**

   LAP protocols are basically a data link layer protocols that are required for framing and transferring data across point-to-point links. It also includes some reliability service features. There are basically three types of LAP i.e. LAPB (Link Access Procedure Balanced), LAPD (Link Access Procedure D-Channel), and LAPF (Link Access Procedure Frame-Mode Bearer Services). It is actually originated from IBM SDLC, which is being submitted by IBM to the ISP simply for standardization.

7. **Network Control Protocol (NCP) –**

NCP was also an older protocol that was implemented by ARPANET. It basically allows users to have access to use computers and some of the devices at remote locations and also to transfer files among two or more computers. It is generally a set of protocols that is forming a part of PPP. NCP is always available for each and every higher-layer protocol that is supported by PPP. NCP was replaced by TCP/IP in the 1980s.

DQDB

IEEE 802.6 standard i.e. DQDB(Distributed Queue Dual Bus) is a MAN(Metropolitan Area Network) protocol. It can be defined as a high speed shared medium access control protocol that is used over a bus network. It has two unidirectional buses, for controlling purposes, where the bus can carry data, video, and voice over a network with bandwidth being allocated as per time slots. The advantage of using the paired bus is that it is used to tackles failure configuration. It can be extended up to 30 miles at 34-55 Mbps.

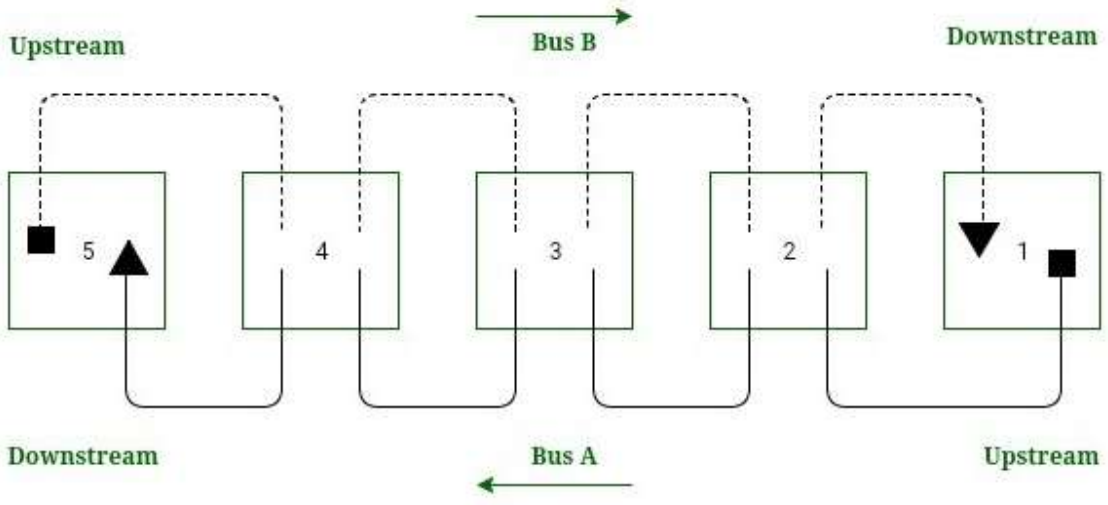


Fig.1:- Working of DQDB

Directional Traffic:

Each bus support traffic in only one direction and are opposite to one another. The start of the bus being represented as a *square* and the end of the bus being represented as a *triangle* (Fig.1). Bus A traffic moves from right to left (i.e. from station 1 to 5) whereas the bus B traffic moves from left to right (i.e. from station 5 to 1).

Upstream and Downstream:

The relationship of stations of the DQDB network depends on the directional flow of traffic of the buses.

Considering bus A in Fig.1, which has station 1 & 2 marked as upstream w.r.t station 3 and

station 4 & 5 are downstream w.r.t station 3. Here in bus A, station 1 is head of the bus as there is no upstream station and station 5 has no downstream station and it is regarded as to end of bus A.

Working:

The head of the bus A i.e. station 1 generates empty slot for use of bus A. Similarly, the head of bus B i.e. station 5 generate empty slot for use of bus B. The empty slot travels down its bus until the transmission station drops data into it and intended destination reads the data.

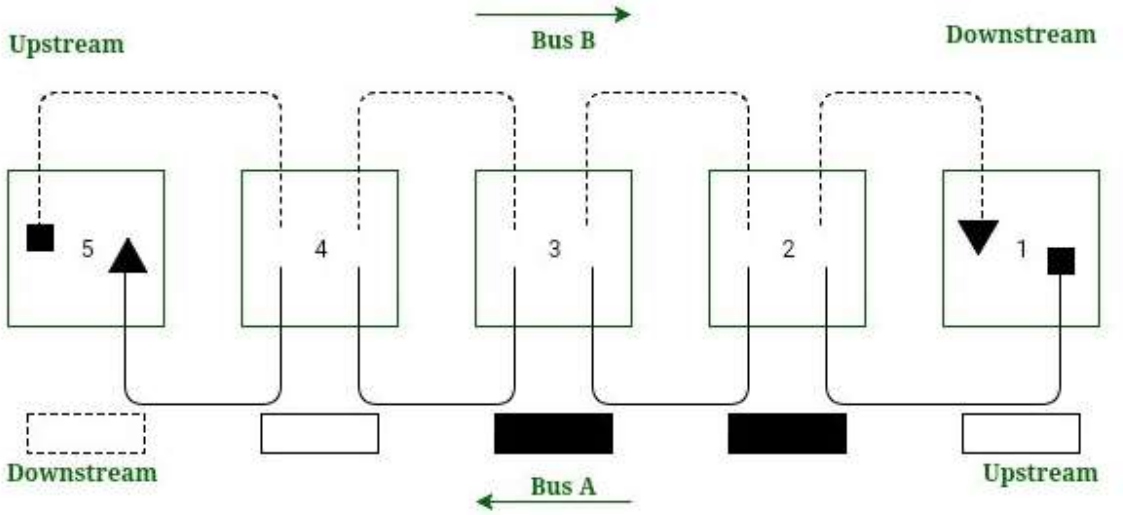


Fig.2:- DQDB Slot traveling

For example:

If station 2 wants to send data to station 4 (Fig.2), it chooses a slot on bus A as station 4 is downstream in bus A. The head of the bus A i.e. station 1 creates an empty slot. Station 2 drops its data & address of destination slot into the passing slot. Station 3 reads the address and passes the slot as unread. Station 4 recognizes its address, reads the data and changes the status of the slot and passes it along with station 5 where it is absorbed.

How slot reservation is done?

To send data downstream, a station must wait for the arrival of the unoccupied slot, but here the question arises that how to stop an upstream station from manipulating the bus due to which the station near the end of the bus suffers, as the imbalance can lead to degraded quality of service. The solution to this problem is to do a reservation at the station. Here station 2 can make a reservation for bus A on bus B. Station 2 sets a reservation bit on a slot on bus B to tell each station it passes through, that the station is reserving a slot on bus A. All the station must respect the reservation of downstream station and leave the slot for requested station.

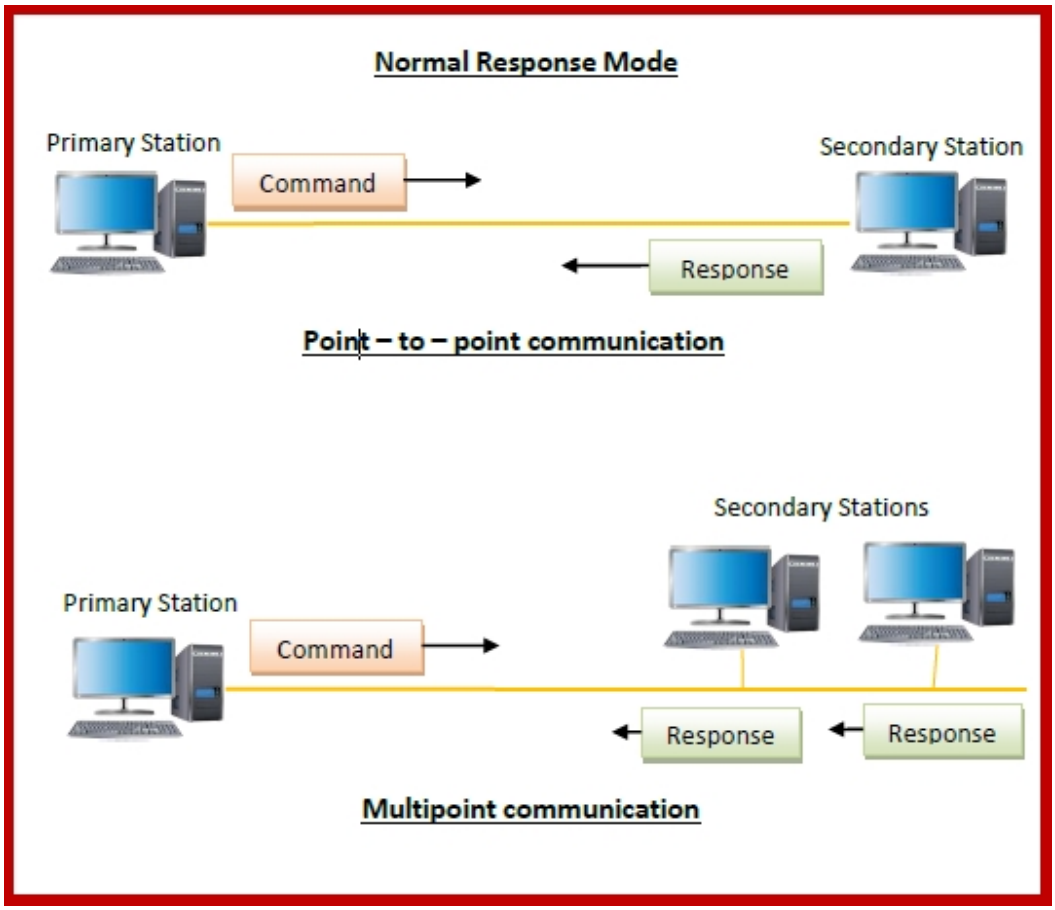
High-level Data Link Control (HDLC)

High-level Data Link Control (HDLC) is a group of communication protocols of the data link layer for transmitting data between network points or nodes. Since it is a data link protocol, data is organized into frames. A frame is transmitted via the network to the destination that verifies its successful arrival. It is a bit - oriented protocol that is applicable for both point - to - point and multipoint communications.

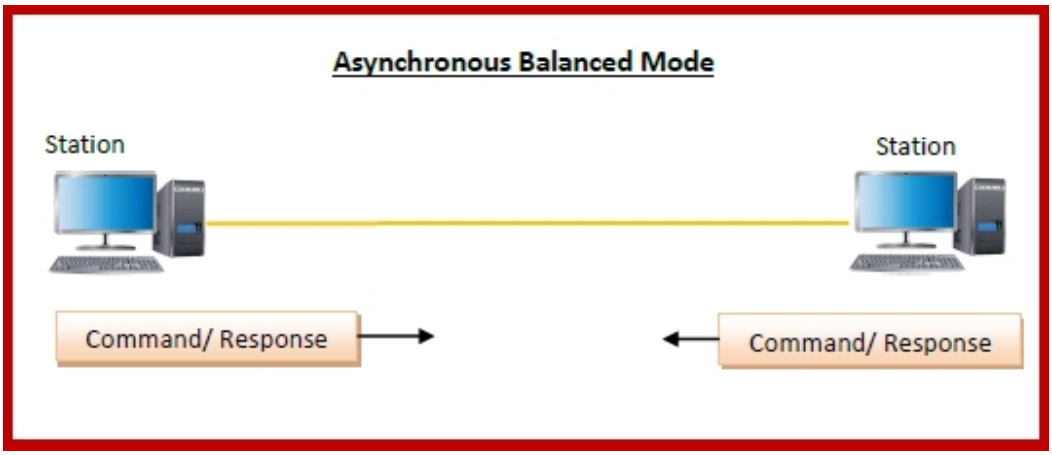
Transfer Modes

HDLC supports two types of transfer modes, normal response mode and asynchronous balanced mode.

- **Normal Response Mode (NRM)** − Here, two types of stations are there, a primary station that send commands and secondary station that can respond to received commands. It is used for both point - to - point and multipoint communications.



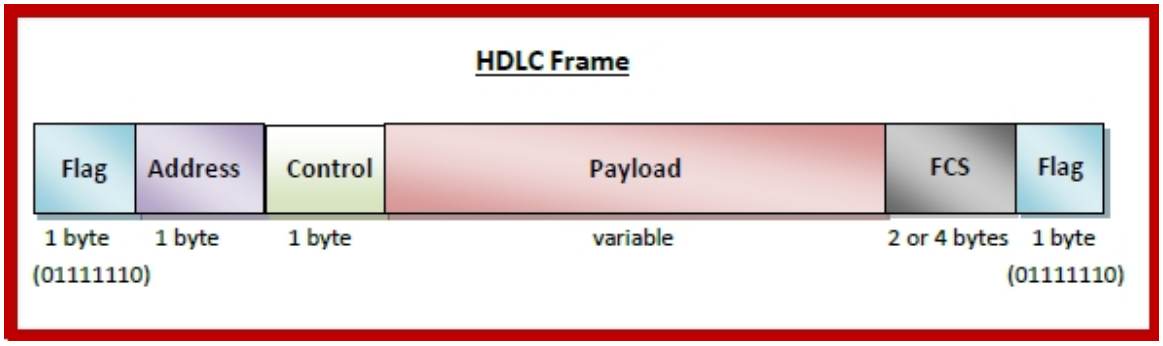
- **Asynchronous Balanced Mode (ABM)** − Here, the configuration is balanced, i.e. each station can both send commands and respond to commands. It is used for only point - to - point communications.



HDLC Frame

HDLC is a bit - oriented protocol where each frame contains up to six fields. The structure varies according to the type of frame. The fields of a HDLC frame are −

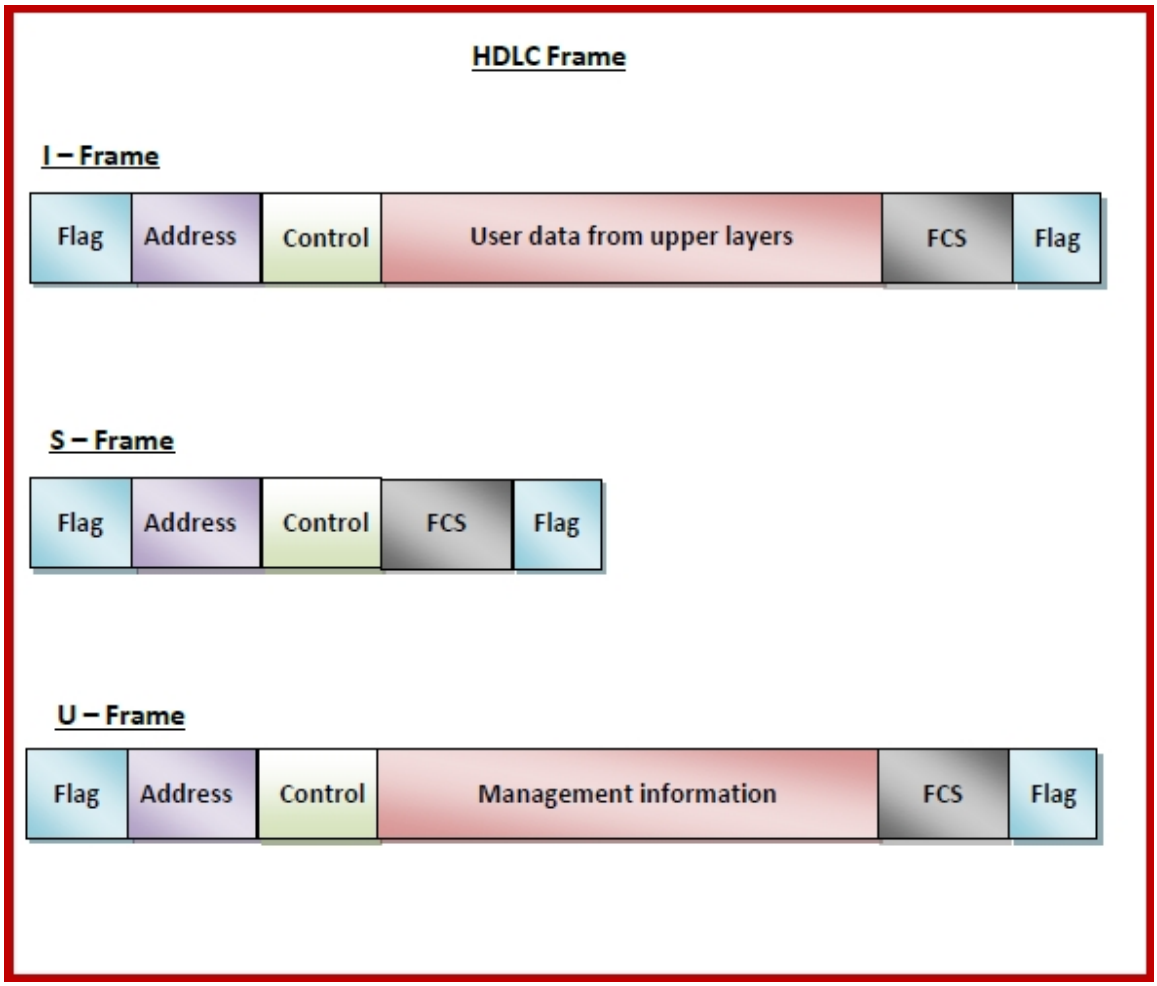
- **Flag** − It is an 8-bit sequence that marks the beginning and the end of the frame. The bit pattern of the flag is 01111110.
- **Address** − It contains the address of the receiver. If the frame is sent by the primary station, it contains the address(es) of the secondary station(s). If it is sent by the secondary station, it contains the address of the primary station. The address field may be from 1 byte to several bytes.
- **Control** − It is 1 or 2 bytes containing flow and error control information.
- **Payload** − This carries the data from the network layer. Its length may vary from one network to another.
- **FCS** − It is a 2 byte or 4 bytes frame check sequence for error detection. The standard code used is CRC (cyclic redundancy code)



Types of HDLC Frames

There are three types of HDLC frames. The type of frame is determined by the control field of the frame −

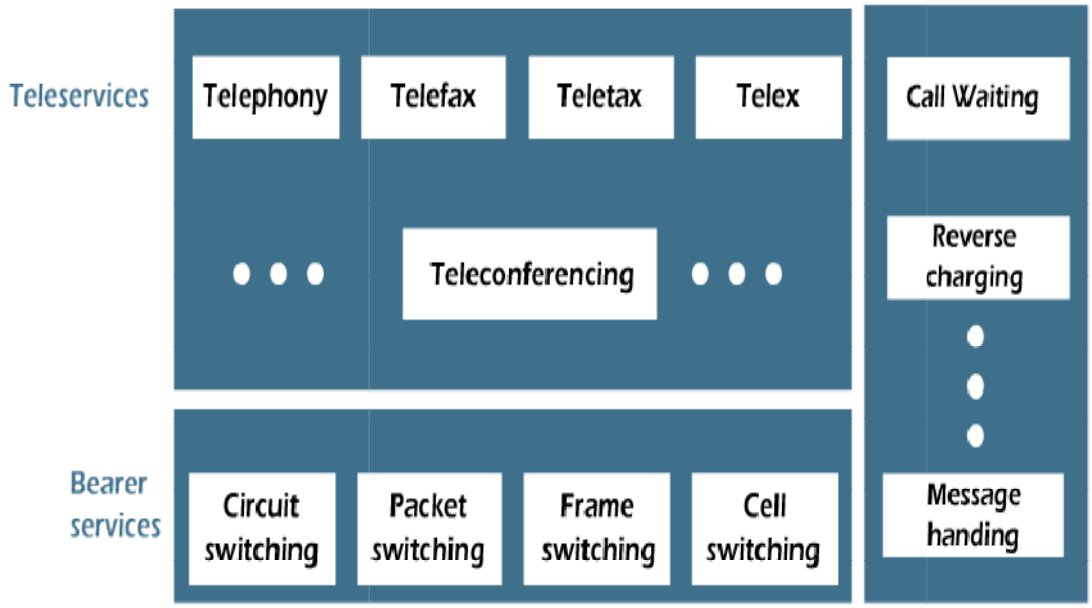
- **I-frame** − I-frames or Information frames carry user data from the network layer. They also include flow and error control information that is piggybacked on user data. The first bit of control field of I-frame is 0.
- **S-frame** − S-frames or Supervisory frames do not contain information field. They are used for flow and error control when piggybacking is not required. The first two bits of control field of S-frame is 10.
- **U-frame** − U-frames or Un-numbered frames are used for myriad miscellaneous functions, like link management. It may contain an information field, if required. The first two bits of control field of U-frame is 11.



Integrated Services Digital Network

ISDN is a set of protocols that is based on high-speed fully digitized telephone service. The main aim of ISDN is to provide a fully integrated digital service to the users.

In ISDN there are following three types of ISDN services:



Bearer Services:

This type of services is used to transfer information such as voice, data, and video between the users without manipulating the content of the network information. It belongs to the first 3 layers of the OSI reference model.

Tele Services:

In these types of services, the network may change the contents of the data. It belongs to the last 4 layers of the OSI reference model. It includes telephony, tele box, fax, and teleconferencing etc.

Supplementary Services:

It provides additional functionality to the bearer services and teleservices. Some of the examples of supplementary services are reverse charging, call waiting, and message handling.

Principles of ISDN:

Following are the principles of ISDN are:

- It supports both circuit switching & packet switching with the connections at 64 kbps.
- In ISDN layered protocol architecture is used for specification.
- ISDN services provides maintenance.
- ISDN services includes some network management functions.
- In ISDN network several configurations are possible for implementing.

ISDN SERVICES:

Following are the two types of services associated with ISDN:

Basic Rate Interface:

In the Basic Rate Interface digital pipe consists of 2 B channels and a 1 D channel. Therefore it is denoted as "2B + 1 D". These two B channels have a data rate of 64 kbps each, and the D channel have a data rate of 16 kbps. It has also a usable bandwidth of 144 kbps.

Basic Rate Interface allows the concurrent use of voice and various data applications such as packet-switched access, a link to a central alarm service, video, tax, etc. The signaling information for the two channels is sent onto the D channel. The two B channels can be used for one 128 kbps connection or two independent connections on the two channels.

The following figure shows the basic structure of the frame in the Basic Rate Interface is:

Basic Rate Interface (BRI)

This service is used to meet the needs of most individual users, including residential and small offices. In this case, the two B channels and the D channel are multiplexed with overhead bits in the form of the frame structure. The overhead bits include framing, DC balancing, and other bits.

The 48 bit frame consists of

- 16 bits of B1 Channel
- 16 bits of B2 Channel
- 4 bits of D channel
- 12 overhead bits

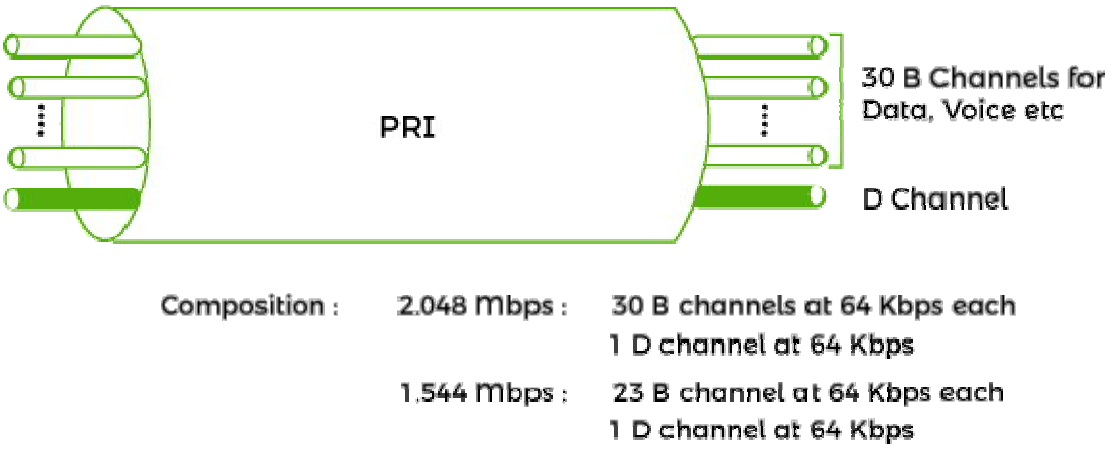
The frame is transmitted in 250 µsec, which results in the following bit rates:

- In frame each B channel = 16 / 250 µsec = 64 kbps
- In frame D channel = 4 / 250 µsec = 16 kbps
- In frame Overhead Bits = 12 / 250 µsec = 48 kbps
- In frame Overall Bit rate = 48 / 250 µsec = 192 kbps

Primary Rate Interface:

Primary Rate Interface consists of either 23 B channels or 30 B channels and a one 64 Kbps D channel. In North America and the Japan, 23 B channels and one D channel are used. It is also denoted by '23 B + 1 D'. In addition, the Primary Rate Interface service itself uses 8 kbps of overhead. Therefore 23D + 1D requires a data rate of 1.544 Mbps. In the case of 30 B channels and one D channel, the total bit rate is 2.048 Mbps.

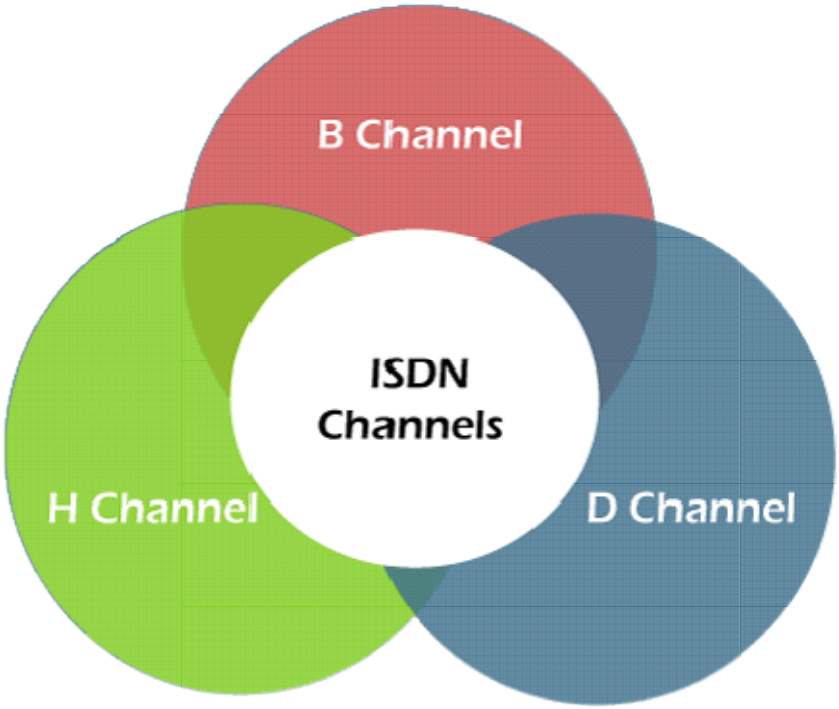
The following figure shows the basic structure of the frame in the Primary Rate Interface is:



ISDN CHANNELS:

ISDN structure have a central ISDN office in which all the users are linked to this through a digital pipe. This digital pipe have different capacities and have a different data transfer rates and these are organized into multiple channels of different sizes.

ISDN standard have the following three types of channels:



B Channel:

It stands for Bearer channel. It has a 64 kbps standard data rate. It is a basic user channel and can carry any digital information in full-duplex mode. In this transmission rate does not exceed 64 kbps. It can carry digital voice, digital data, and any other low data rate information.

D Channel:

It stands for Data Channel. This channel carry control signal for bearer services. This channel is required for signaling or packet-switched data and all-controlling signals such as establishing calls, ringing, call interrupt, etc.

H Channel:

It stands for Hybrid Channel. It provides user information at higher bit rates.

There are 3 types of Hybrid Channel depending on the data rates. Following are the hybrid channels types:

- Hybrid Channel 0 with 384 kbps data rate.
- Hybrid Channel 11 with 1536 kbps data rate.
- Hybrid Channel 12 with 1920 kbps data rate.

ISDN Devices:

Following are the types of ISDN devices:

TE1: Terminal equipment type (TE1) are specialized ISDN terminals. It includes digital telephone instruments such as FAX, or data terminal equipment. All these devices have an S-bus ISDN interface.

TE2: Terminal equipment type (TE2) is Non-ISDN compatible is connected through a Terminal Adapter. It includes analog phones and 3270 terminal Fax.

TA: It stands for Terminal Adapter. This device acts as an intermediary device for non-ISDN terminal devices. It converts the non-ISDN interface of these devices to the ISDN interface. The ISDN terminal Adapter can be either a standalone device or a board inside the Terminal equipment type 2. Some of the examples of Terminal adapter are EIA/TIA-232-C, V.24 etc.

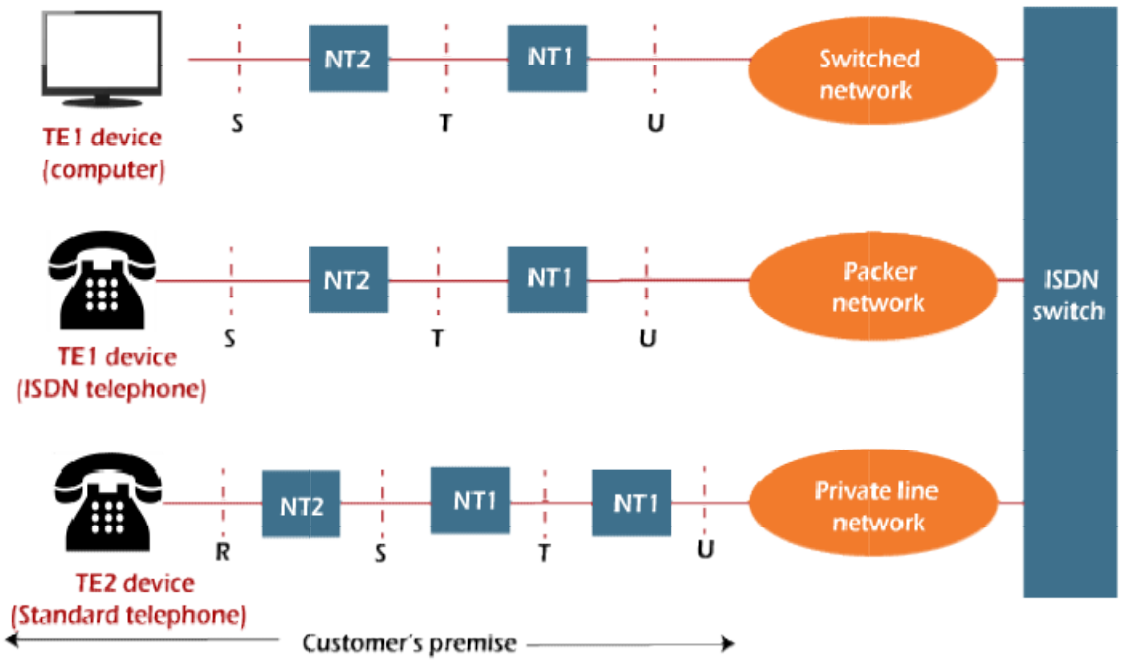
NT1: It stands for Network termination type 1. It provides a line termination at the customer's premise. They can also provide line monitoring, power feeding, error statistics, and proper timing.

NT2: It stands for Network termination type 2. It provides a switching, multiplexing, concentrating, or distributing information for the customer's premises. Some examples of Network termination type 2 are this could be a LAN server or Private Branch Exchange etc.

ISDN Reference Points:

It specifies the number of reference points that provide interfaces between the adjacent devices.

Following Figure displays the working of ISDN reference points:



In the above figure it shows an ISDN configuration in which 3 devices attached to an ISDN switch at the central office. In which 2 devices are ISDN compatible and they are attached through the S reference point to Network termination type 2 devices. Out of these third device is a standard non-ISDN telephone and is attached to a Terminal Adapter through an R reference point.

These reference points are R, S, T, and U.

- **R:**It stands for Rate transfer point. It is an interface for non-ISDN devices and therefore is the reference point between non-ISDN equipment and a Terminal Adapter. It can be RS-232-C, V, or X series of ITU-T standard or ordinary telephone interface with two wires.
- **S:**It stands for System transfer point. The interface between the user terminal and NT2. It is a four-wire balanced to which upto eight ISDN terminals can be connected. The physical connector for S - interface on terminals and NT1 is an 8-pin RJ-45 connector.
- **T:**It stands for Terminal transfer point. It is the interface between Network termination type 1 and Network termination type 2

- **U:** It is the interface between Network termination type 1 device and the line termination equipment in the carrier network. The U interface is the local copper pair of the access network. The same pair is used for full-duplex transmission of digital signals.

Asynchronous Transfer Mode (ATM) in Computer Network

We use an Asynchronous Transfer Mode (ATM) network because it is driven by the integration of performance and service, which is the requirement for both data network and telephony. It also provides network support for the single quality of the service, and these services are very expensive. It is very cheap and flexible. It also supports some ranges of services at a reasonable cost.

Asynchronous Transfer Mode (ATM)

Asynchronous Transfer Mode (ATM) is an International Telecommunication Union-Telecommunications Standards Section (ITU-T) that is very efficient for the relay of calling. Also, it is used to transfer all the services like voice, data, or video. These services can be conveyed in a small fixed-sized packet called the cell. These cells are connected in a network that transmits the data asynchronously.

Asynchronous transfer mode (ATM) is a technology that was developed in the year between 1970 and 1980. This was considered the revolution in packet switching. Each cell consists of 53 bytes longs. Further, the 53 bytes long can be divided into 5 bytes header and 48 bytes payload. Before making an ATM call, we need to send a message to set up the connection.

All the cells follow the same path connected to the destination. The cell can also handle both variable and constant rate traffic. Thus it has multiple types of traffic with end-to-end encryption. Asynchronous transfer mode (ATM) does not depend on the transmission medium. Asynchronous transfer mode (ATM) uses cell or packet switching and virtual circuits to switch the transmission medium. The main purpose of designing the Asynchronous transfer mode (ATM) is to help implement high-performance multimedia networking.

ATM Cell Format

In Asynchronous transfer mode (ATM), the data are transmitted through a fixed-size unit called cells. As we know, each cell has 53 bytes long. There are two types of Asynchronous transfer modes (ATM). These are as follows:

1. UNI header

This is used in the private connection in the Asynchronous transfer mode (ATM) network between ATM switches and ATM endpoints.

2. NNI header

It communicates between the Asynchronous Transfer Mode (ATM) switches.

Working of ATM

Two types of connection use the Asynchronous transfer mode (ATM). A virtual path can be created end-to-end across an ATM network, as it does not route the cells to a particular virtual circuit. In case of major failure, all cells belonging to a particular virtual path are routed the same way through the ATM network, thus helping faster recovery.

Switches connected to subscribers use both VPIs and VCIs to switch the cells, which are Virtual Path and Virtual Connection switches that can have different virtual channel connections between them, serving the purpose of creating a **virtual trunk** between the switches, which can be handled as a single entity. Its basic operation is straightforward looking up the connection value in the local translation table, determining the outgoing port of the connection, and the new VPI/VCI value of the connection on that link.

ATM vs. DATA Networks (Internet)

- **ATM is a "virtual circuit" based:** Here, the path is reserved before transmission. While Internet Protocol (IP) is connectionless, end-to-end resource reservations are impossible. RSVP is a new signaling protocol on the internet.
- **ATM Cells:** Fixed or small, and the Tradeoff is between voice or data. At the same time, IP packets are of variable size.
- **Addressing:** ATM uses 20-byte global NSAP addresses for signaling and 32-bit locally assigned labels in cells. At the same time, IP uses 32-bit global addresses in all packets.

ATM Applications

1. ATM WANs

To send the data over a long distance, we use WAN and a router to connect ATMs and other networks.

2. Multimedia virtual private networks and managed services

It helps manage ATM, LAN, voice, and video services and is capable of full-service virtual private networking, including integrated multimedia access.

3. Frame relay backbone

Frame relay services are a networking infrastructure for a range of data services and enable frame-relay ATM service to Internetworking services.

4. Residential broadband networks

ATM by choice provides the networking infrastructure for establishing residential broadband services in search of highly scalable solutions.

5. Carrier infrastructure for telephone and private line networks

To make more effective use of SONET/SDH fiber infrastructures we build the ATM infrastructure to carry out the telephonic and private-line traffic.