# Unit – 5

What is the full form of DSL

DSL: Digital Subscriber Line

DSL stands for Digital Subscriber Line. DSL is a communication medium used to transfer high speed internet over standard copper wire telecommunication line. DSL offers the best cost, connectivity and services over other internet access types like broadband.

Data transfer and telephone conversation can be done simultaneously over a DSL. Over the 'voiceband' frequency range, voice signal is transmitted using low frequencies (0Hz to 4kHz). While digital signals are transmitted through high frequencies (25kHz to 1.5MHz). To make sure that phone call does not get interrupted by high frequencies, DSL filters or splitters are used.
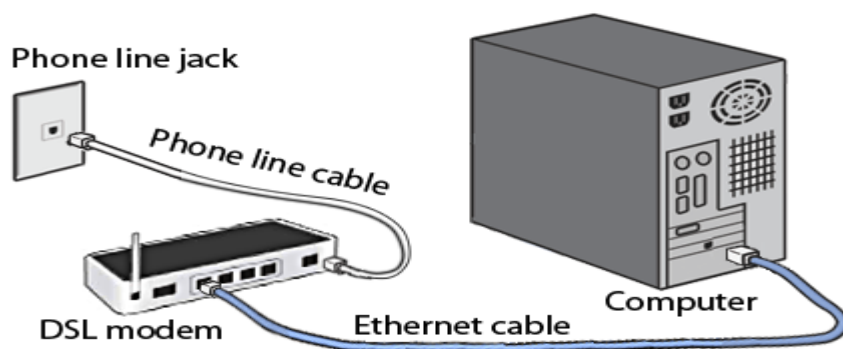
Types of DSL
- **SDSL:** Symmetric DSL provides equal bandwidth for both uploading and downloading and is mostly preferred by small organizations.
- **ADSL:** Asymmetric DSL. Most users download more data then they upload, for this they use ADL. In this, downstream speed is much more than upstream. Uploading capacity may not work as good as downloading capacity. Users who do not upload that much in comparison to downloading can use ASDL. It may offer as high as 20 Mbps speed for downloading while for uploading 1.5 Mbps.
- **HDSL:** It is high bit-rate Digital Subscriber Line. It is a wideband digital transmission which is used within a corporate site and between the telephone company and its customers. It is a symmetrical line, offers equal bandwidth in both directions.

- o **RADSL:** It is Rate-Adaptive DSL. In this DSL technology, the modem is capable of adjusting bandwidth and operating speed to maximize the data transfer. It supports both symmetrical and asymmetrical applications with variable speeds.
- o **VDSL:** It is very high data rate DSL. It is a developing DSL technology that offers more reliable internet experience than basic broadband. It offers much higher data transfer rate over short distances, e.g. 50 to 55 Mbps over lines up to 300 meters in length.

Features

- o It is widely available.
- o It is less costly, offers more security.
- o It is much reliable than other broadband service.
- o It offers less speed than broadband service.
- o It provides a limited range due to which internet quality is affected due to larger distance between main hub DSL provider and receiver.

Benefits –

- **No Additional Wiring** – A DSL connection makes use of your existing telephone wiring, so you will not have to pay for expensive upgrades to your phone system.
- **Cost-Effective** – DSL internet is a very cost-effective method and is best in connectivity
- Availability of DSL modems by the service providers.
- Users can use both telephone lines and the internet at the same time. And it is because the voice and digital signals are transferred in different frequencies.
- Users can choose between different connection *speeds* and *pricing* from various providers.

DSL Internet service only works over a limited physical distance and remains unavailable in many areas where the local telephone infrastructure does not support DSL technology. The service is not available everywhere. The connection is faster for receiving data than it is for sending data over the Internet.

What are the Computer Cables?

A cable, also known as a cord, plug, or connector transmits power or data between devices or positions, which is covered in plastic by one or more

wires. A power cable and data cable are the primary types of computer cables. The cable that creates communication between devices is known as a data cable. For instance, DVI, HDMI, or VGA are all the data cables that are used to attach to the computer monitor and enable it to display an image or picture on the computer monitor. The USB>/a>, SATA, CAT5, and IDE/EIDE cables are other popular examples of data cables. A cable that powers the device is known as a power cable. For instance, inside the computer, a Molex-style cable and the power cord that attaches to computer.

Types of Computer Cables

There are multiple parts available in the computer that is associated with the system, which is either connected directly or needs some cable to connect computer parts to the system. The parts in the computer system can be mice, Digital cameras, hard drives, or others. There are several types of cables available in the market with a different purpose; these cables are computer power cord cable, Ethernet cable, DVI cable, HDMI cable, PS/2 cable, USB cable, 3.5 mm audio cable, and VGA cable. Below is a list that contains the most common kinds of computer cables:

HDMI cable

HDMI is a type of computer cable that has the potential to transmit audio and video signal with the original quality of images. It stands for High Definition Multimedia Interface, which can send crystal clear images. The use of HDMI cable is to connect electronic devices such as TVs, cable boxes, HDTV, Projector, media streamers, DVD players, and more. HDMI cable, one standard cable, can be used to connect all types of Av devices. Additionally, it has the ability to transmit audio and video signals in one go. The below picture is of an HDMI cable.

DVI cable

DVI cable is a video display interface, which is used to connect the video card and LCD monitor and stands for Digital Visual Interface. Without having any disturbance, users can see pictures of high quality with the help of using this cable. It is able to transmit video content to display devices at high resolutions, 2560 x 1600 resolutions and is mostly used in CRT monitors, which have a VGA connection. The primary intention to develop it was to be an industry standard for transmitting digital and analog signals to the computer system.

Due to some DVI cables that can only transmit audio signals, HDMI is more common to use with TVs, but DVI even widely be used with some TVs. On the basis of the supported signals, one of the three names may be included in DVI connector: DVI-I (both digital and analog), DVI-D (digital only), or DVI-A (analog only). It is very easy to differentiate DVI cable is analog or digital. If only a flat pin present on the cable, it is known as DVI digital. If there is a flat pin and a pin contains four pins around, it is called as a DVI analog.

VGA cable

Another kind of computer cable is VGA cable that is developed by IBM and introduced in 1987. It stands for Video Graphics Array or Video Graphics Adapter, which is used to link the monitor and the CPU of a computer and transfer video signals. HD televisions also use the VGA cable, 256 colors are shown if the resolution is lowered to 320 x 200; however, it offers 640 x 480 resolution color display screens. In modern times, it is common to find VGA cable and connector with computers, even TVs, and projectors. However, DVI, HDMI, DisplayPort cable, and connector are becoming the reason to replace VGA cable. The picture of the VGA cable is shown below.

Ethernet Cable

The Ethernet cable is generally used for a wired network, and the quality of the connection is described by the length and durability of the Ethernet cable. It can be used to connect the devices such as PCs, routers, and switches within a LAN, and the quality of the connection will not be best if the cable is not durable and too long. This may create a problem sometimes; therefore, there are several kinds of Ethernet cable available that you can buy easily from the market. The Ethernet port is presented on the motherboard, which is used to plug Ethernet cable. This cable looks similar to a phone cable, but it has more wires as compared to a phone. Additionally, users can buy Ethernet cable in different colors, and it contains eight wires. The below image is of an Ethernet cable.

PS/2 Cable

The PS/2 cable is a standard cable, which contain a round connector and a total of 6 pins, and generally, two sizes of PS/2 cable are available on the market. It is used to attach the mouse and keyboard to the computer system, and its length is long enough. It stands for Personal System/2 that was developing by IBM. The most common cable is the smaller size, but there are some adaptors available that can be used to increase its size. But USB cables are replacing them because they can be easily plugged and are universal cables. The example of PS/2 cable is given below:

5mm Audio Cable

The 3.5mm audio cables are the type of computer cable that are simply used to connect earphones and headphones to the system. Commonly, they are used for connecting mini-stereo audio device, a PC sound card, or any portable CD player to any multimedia speaker.

USB cables

The USB cable is a popular, standard cable that enables a computer device to interact with peripheral and other devices. It stands for Universal Serial Bus, and there are various devices that are connected through USB cable, such as keyboards and mice, music players and flash drives, etc. Its first version, 1.0, was released in January 1996, which was later adopted by companies like Microsoft, Compaq, Intel, and others. The USB ports are presented on the computer system, which is used to connect USB cables. For example, mice and keyboards have a USB cable that is connected to the computer. Whenever the device is connected through the USB cable, and you need to remove the USB cable while the device is running, first you should eject safely, and then you can remove it from the system. The below picture is an example of a USB cable.

MIDI

MIDI is a simple procedure to connect two different musical components of different brands; it was first developed in the 1980s. It stands for Musical Instrument Digital Interface, which can carry panning, music data, event messages, vibrato, and more. Generally, it is a standard that acts as a remote control for the music gear and digitally representing and transmitting sounds. On the sound module, users can use a keyboard and change the tempo, pitch, and volume of a note. A MIDI cable provides more control over the other equipment as it does not transfer the audio signal and transfer the messages in the form of data.

There are many earlier computer systems in which sound cards contain MIDI port that connects electronic musical instruments and computers. The devices like a MIDI keyboard or a synthesizer can be connected to the computer through a MIDI cable.

Molex

It is a power cable that is used inside the computer. Molex is not the cable name. It is the name of the company that develops computers and other related equipment. It is also referred to as a 4-pin connector or Molex power connector, which is used to attach DC power to the drives and devices inside the computer. Inside the computer, a Molex connector is used by almost all devices. The common devices are a Video card, Hard drive, and Disc drive (e.g., CD-ROM, DVD, Blu-ray).

SATA

SATA is an interface that is developed to replace parallel ATA interface used in IBM compatible computers, which is also known as 'Serial ATA.' It is an interface used with hard drives and its first version 1.0, was released in August 2001. It provides a small, thin cable solution that transfer rates start at 150MBps. It is backward-compatible with ATAPI and ATA devices, and as compared to the earlier ribbon cables, it gives better airflow in the computer. As compared to the dated PATA standard, it is a more efficient and better interface.

SCSI

SCSI is pronounced as "Scuzzy" and stands for Small Computer Systems Interface, which has the potantial to support eight devices or sixteen devices with Wide SCSI. It was first completed in 1982 and designed to connect devices to a computer. It is commonly used with the disc, hard, and tape drives and all devices are "daisy-chained" together and connect to a central bus as it is a bus technology.

On the basis of the location of the SCSI bus, its requirements are dependent, and a SCSI connector is either external or internal. Three different signaling types are used by the SCSI, such as LVD (low-voltage differential), Single-Ended (SE), and Differential, which may be HVD or

high-voltage differential. Furthermore, SCSI connections may also be available on a more advanced motherboard.

Thunderbolt

Thunderbolt is a relatively new technology that is used to connect peripheral devices to a computer and is primarily used with Apple displays and devices. It offers users the benefit of adding several devices to their computers through a daisy chain of cords. By using one port with a cable, it allows users to use one cable to access high-resolution and high-speed media that can access both PCI Express and DisplayPort. Thunderbolt is a fairly new peripheral connection technology that was developed by Apple and Intel.

Advantages of Computer Cables

The cables are very important for a computer to connect several devices inside or outside the computer system. For performing different operations, computer cables are used to transmit the digital and analog signals. Like USB cables, some of the computer cables have the ability to transmit electric power. Users can also do many more things by using computer cables, such as listen to music, watch movies, play games, and more.

DSL vs. Cable

DSL uses telephone lines and is the slowest option, whereas cable transmits data over copper TV lines, works faster, and carries more bandwidth. DSL is widely available because almost every part of the country has access to phone service, so it's a great option for people in rural areas who don't want to choose satellite internet. Cable is ideal if you stream on multiple devices, hop on a lot of video calls, or

download large files, while DSL is better if you only check your email every once in a while and casually surf the internet.

Cable vs. Fiber

Fiber internet provides a high-bandwidth connection and speeds up to 1 Gbps. Cable speeds can be as fast as fiber, but they slow down during peak use times when all your neighbors get home from work and watch Netflix or a big game. That said, cable covers about 88 percent of the U.S. at an average speed of 10 to 500 Mbps. Fiber is great for competitive online gamers or someone who wants the fastest speed available and lives in larger cities where it's available. If you want extremely fast internet, then **AT&T Internet** is a top contender.

DSL vs. Fiber

DSL and fiber are complete opposites when it comes to speeds and coverage. Fiber is new, so it has less coverage than DSL, but **fiber expansion projects** are under way. DSL usually runs over pre-existing lines, making setup easy. On the other hand, fiber requires professional installation services to run the fiber-optic cables to your house. **Internet providers such as CenturyLink** offer both DSL and fiber plans.

How does Frame Relay Work?

Frame Relay is a packet-switching network protocol that is designed to work at the data link layer of the network. It is used to connect Local Area Networks (LANs) and transmit data across Wide Area Networks (WANs). It is a better alternative to a point-to-point network for connecting multiple nodes that require separate dedicated links to be established between each pair of nodes. It allows transmission of different size packets and dynamic bandwidth allocation. Also, it provides a congestion control mechanism to reduce the network overheads due to congestion. It does not have an error control and flow management mechanism.
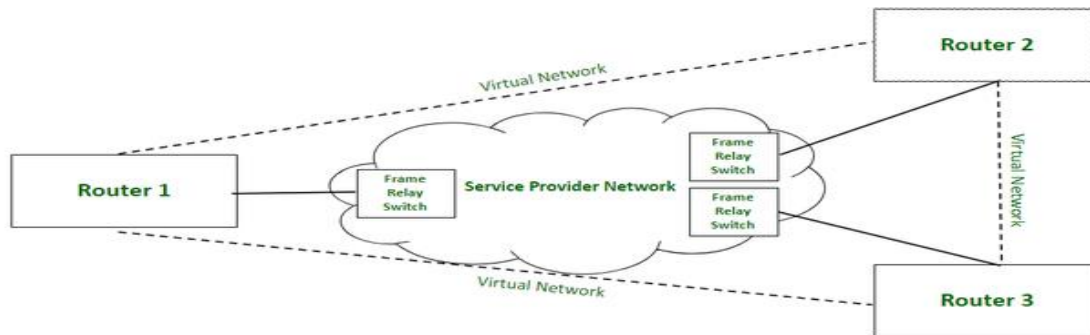
Frame Relay Network

Working:

Frame relay switches set up virtual circuits to connect multiple LANs to build a WAN. Frame relay transfers data between LANs across WAN by dividing the data in packets known as frames and transmitting these packets across the network. It supports communication with multiple LANs over the shared physical links or private lines.

Frame relay network is established between Local Area Networks (LANs) border devices such as routers and service provider network that connects all the LAN networks. Each LAN has an access link that connects routers of LAN to the service provider network terminated by the frame relay switch. The access link is the private physical link used for communication with other LAN networks over WAN. The frame relay switch is responsible for terminating the access link and providing frame relay services.

For data transmission, LAN's router (or other border device linked with access link) sends the data packets over the access link. The packet sent by LAN is examined by a frame relay switch to get the Data Link Connection Identifier (DLCI) which indicates the destination of the packet. Frame relay switch already has the information about addresses of the LANs connected to the network hence it identifies the destination LAN by looking at DLCI of the data packet. DLCI basically identifies the virtual circuit (i.e. logical path between nodes that doesn't really exist) between source and destination network. It configures and transmits the packet to frame relay switch of destination LAN which in turn transfers the data packet to destination LAN by sending it over its respective access link. Hence, in this way, a LAN is connected with multiple other LANs by sharing a single physical link for data transmission.

Frame relay also deals with congestion within a network. Following methods are used to identify congestion within a network:

1. **Forward Explicit Congestion Network (FECN) –**
   FECN is a part of the frame header that is used to notify the destination about the congestion in the network. Whenever a frame experiences congestion while transmission, the frame relay switch of the destination network sets the FECN bit of the packet that allows the destination to identify that packet has experienced some congestion while transmission.

2. **Backward Explicit Congestion Network (BECN) –**
   BECN is a part of the frame header that is used to notify the source about the congestion in the network. Whenever a frame experiences congestion while transmission, the destination sends a frame back to the source with a set BECN bit that allows the source to identify that packet that was transmitted had experienced some congestion while reaching out to the destination. Once, source identifies congestion in the virtual circuit, it slows down to transmission to avoid network overhead.

3. **Discard Eligibility (DE) –**
   DE is a part of the frame header that is used to indicate the priority for discarding the packets. If the source is generating a huge amount of traffic on the certain virtual network then it can set DE bits of less significant packets to indicate the high priority for discarding the packets in case of network overhead. Packets with set DE bits are discarded before the packets with unset DE bits in case of congestion within a network.

Types:

1. **Permanent Virtual Circuit (PVC) –**
   These are the permanent connections between frame relay nodes that exist for long durations. They are always available for communication even if they are not in use. These connections are static and do not change with time.

2. **Switched Virtual Circuit (SVC) –**
   These are the temporary connections between frame relay nodes that exist for the duration for which nodes are communicating with each other and are closed/ discarded after

the communication. These connections are dynamically established as per the requirements.

Advantages:

1. High speed
2. Scalable
3. Reduced network congestion
4. Cost-efficient
5. Secured connection

Disadvantages:

1. Lacks error control mechanism
2. Delay in packet transfer
3. Less reliable

ATM - Automated Teller Machine

ATM is the abbreviation of **Automated Teller Machine**. In old days, people used to stand in long queues in front of the banks to collect their salaries. Now, people visit the ATM nearest to their place and enjoy safe transactions.

What is an ATM

An automated teller machine facilitates the transactions without involving a bank employee to deal with the customer's transaction. It has made transactions easy and hassle-free. Additionally, it has significantly reduced the bank workload. For any individual to complete transactions using an ATM

, it is necessary to have a credit or debit card. Through these cards, any bank account holder can access their balance, or withdraw, deposit, or transfer cash from their account. The customers can perform these functions without visiting their bank branch. Hence successful transactions can be made without filling slips, forms and without standing in long queues.

An ATM charges fees for cash withdrawal. This fee is charged by the bank, the ATM operator, or both. To avoid any fees for cash withdrawal, one should prefer using the ATM of the same bank in which they hold their account. ATMs are known by different names, such as cash machines and automated bank machines (ABM).

How to use an ATM

1. After visiting the ATM, insert the card in the card slot.
2. Select the options from the display of the ATM.
3. Select the function to be performed from the displayed options, which includes deposit, balance inquiry, transfer, and cash withdrawal.
4. Select the account type from the salary, savings, and current.
5. Type the amount which you want to withdraw using the keypad and also provide the ATM pin.
6. Collect your cash from the cash slot.
7. Collect the receipt from the printer.
8. Select the other option instead of cash withdrawal for another transaction like cash depositing.

ATM Cards

ATM cards help the user to access their account through ATM. It is a plastic card that contains the customer account information in the form of a magnetic strip. An identification code is encrypted in the magnetic strip and contains all account details of the customer. This identification code is used for the authentication of the customer with the centralized bank. ATM cards are available in India's different forms, including Visa, Mastercard, Maestro, and RuPay cards.

Functions of an ATM

The main functions of ATMs are cash withdrawal, cash deposit, and transfer of money from one account to another. These can be described as -

1. **Cash withdrawal -** Any bank account holder can withdraw cash from their account.
2. **Cash deposit -** Any bank account holder can deposit cash to their account.
3. **Cash transfer -** Any bank account holder can transfer money from one bank account to another.
4. **Balance inquiry -** Any bank account holder can check their available balance and sometimes even a few last transactions.

Types of ATM

The two types of ATMs are basic ATMs and complex ATMs. The function of a basic ATM is usually facilitating cash withdrawal along with an available balance statement. The complex ATM is responsible for multiple functions like displaying account information and providing transaction history and cash deposits.

Some other types of ATMs are discussed below:

Brown Label ATM: A Brown Label ATM is the one in which the service provider of the ATM owns the lease of the machine. Although the lease has been owned by the service provider, the network and connection with the bank are managed by the sponsor bank.

Cash Dispenser: The ATMs that only dispense cash and are used for balance inquiry and mini statement. No other transactions are possible on these

Green Label ATM: Green Label ATM facilitates agricultural transactions.

Mobile ATM: Mobile ATM is the type of ATM which moves from one place to another, providing service to its customers. The covid-19 pandemic has led to the rise in the number of mobile ATMs in the cities.

Off-site ATM: These machines are installed outside the premises of the bank.

On-site ATM: These machines are installed within the premises of the bank.

Orange Label ATM: These ATMs facilitate share transactions.

Pink Label ATM: Pink label ATMs are specially made for women.

White Label ATM: These ATMs are provided by companies that are financial but are in a non-banking domain.

Worksite ATM: These ATMs are installed in the bank premises, but only bank employees can use these.

Yellow Label ATM: These ATMs are used for online shopping.

Design of an ATM

ATM is carefully designed by combining the individual components which are used for a particular function. The parts of the ATM are listed below -

- **Screen:** Screen is used to guide the customers through the various options in a transaction process. The account information like account balance etc., is also displayed on the screen.
- **Keypad:** The keypad is used as an input device to the ATM. It is used to enter a PIN, transaction type, and the amount of cash for any function.
- **Card Reader:** A card reader interprets the account information by reading the card using the magnetic strip.
- **Cash dispenser:** It is an ATM, which is a slot that provides cash to the customer.
- **Printer:** An ATM printer is used to print receipts of transactions whenever a customer requests it. It provides written information which includes the current account balance, etc.

Advantages of ATM

- **Convenience -** ATM is way more convenient than standing in long bank queues to withdraw cash, deposit cash or transfer it.With the wide application and increasing, public demand ATMs are now found in all the public places
- **Not time-bound -** Unlike banks, ATMs are not time-bound and provide24 x 7 hours a week and throughout the year. The money

transactions can be done duringthe day or at night, making ATMs much more convenient to use.

o **Faster transactions -** ATM transactions are faster as compared to bank transactions. Neither standing in long queues nor filling of slips and receipts are required, this has made transactions faster, and people could now save their time.

o **Easy Accessibility -** ATMs are easily accessible in any area. Everyone holding a bank account can withdraw cash from their accounts with the help of ATM cards. The account can be accessed from anywhere worldwide. ATMs are installed in all public places, which gives convenience to the customers.

o **Minimizes the bank workload -** ATMs have supported banks by reducing their workload. The customers can directly approach the bank and do their transactions without visiting the bank branch. Eventually, the bank workload is reduced, and bank employees can manage people efficiently.

o **Minimize transaction cost -** Technological inventions have made transactions automatic without human intervention. ATM usage has reduced the overall cost of transactions as fewerhuman resourcesare utilized in transactions.

Disadvantages of ATM

o **Cash Withdrawal Limit -** There are restrictions on the daily cash withdrawal and even the number of free transactions. Some other restrictions are cash withdrawal at a time. Many bank ATMs have around 25,000 cash withdrawal limits for a single transaction.

o **Transaction Charges of ATM -** Fees id charged for various bank transactions. These are generally standard charges of the bank and sometimes may include the taxes on the transactions. ATM charges vary according to the bank. These can be avoided by using the same bank ATM in which the customer holds the account.

o **Increased Frauds -** Online transactions and ATM transactions are more susceptible to fraud. Through online transactions, hackers can get user data and steal money from customers' accounts.

o **Non-Reachable in the Remote Areas -** Due to the lack of proper structure and maintenance, there is a lack of high-tech banking

systems in the remote areas of India. This has increased the need forhuman resources.

What is Point to Point Protocol (PPP) in Computer Network?

PPP represents Point-to-Point Protocol. It is a protocol that is frequently used to support similar functionality as SLIP. It is the most robust protocol that can share multiple types of packets also along with IP Packets. It can be required for dial-up and hired router-router lines. It usually provides the framing methods to describe frames.

It can support the responsibility and management of IP addresses, asynchronous and bit-oriented synchronous encapsulation, network protocol multiplexing, link configuration, etc. It can provide an extensible Link Control Protocol (LCP) along with Network Control Protocols (NCP).

PPP Components

The point-to-point protocol contains the following components for sharing diagrams over serial point-to-point connections

Encapsulating Diagrams

PPP works the High-Level Data Link Control (HDLC) protocol to encapsulate diagrams over the point-to-point connection. The HDLC protocol describes the boundaries around the single PPP frames and provides a 16-bit checksum.

A PPP frame adds a protocol field to the primary HDLC frame to identify the type of packet transported by the frame to handle packets from protocols other than IP, such as Novell's IPX or Appletalk.

Implementing LCP

An extensible link control LCP can start, generate and test the data-link connections. It is implemented on top of HDLC to construct preferences about the data link.

Implementing NCP

Categorization of network control protocols (NCPs) can start and generate multiple network-layer protocols including IP and Appletalk, routed across the data link. They start powerfully using a similar NCP.

Before sending IP diagrams across the link, both the host running PPP should settle the IP address used by each of them. The control protocol used for such negotiations is known as the Internet Protocol Control Protocol (IPCP).

PPP Frame

The PPP frame format is shown in the figure below –

- **Flag** – It contains a single byte that indicates the starting or end of a frame.
- **Address** – Address contains a single byte that includes the binary sequence. PPP does not enable single-station addresses.
- **Control** – It generates an individual byte that contains the binary sequence, which calls for user data communication. It is a connectionless link function similar to that of Logical Link Control (LLC).
- **Protocol** – It contains two bytes that identify the protocol encapsulated in the frame's data field.
- **Data** – Data can range from zero or more bytes, containing the datagram for the protocol represented in the protocol field. The default largest duration of the data field is 1,500 bytes.
- **Frame Check Sequence (FCS)** – It accepts 2 bytes. In this method, it can also use 4-byte FCS for enhanced error detection but with the earlier agreement.

PPP Frame

1 byte	1 byte	1 byte	2 byte	Variable	2 or 4 byte
Flag	Address	Control	Protocol	Data	FCS
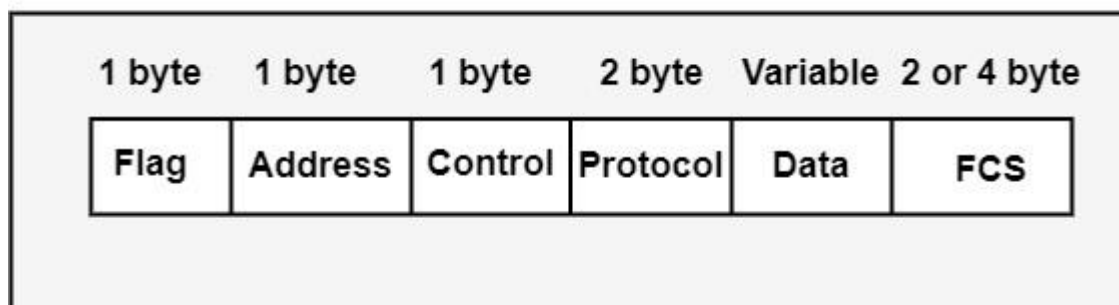
Basic Frame Structure of HDLC

High-Level Data Link Control (HDLC) generally uses term "frame" to indicate and represent an entity of data or a protocol of data unit often

transmitted or transferred from one station to another station. Each and every frame on link should begin and end with Flag Sequence Field (F). Each of frames in HDLC includes mainly six fields. It begins with a flag field, an address field, a control field, an information field, an frame check sequence (FCS) field, and an ending flag field. The ending flag field of one frame can serve as beginning flag field of the next frame in multiple-frame transmissions.

The basic frame structure of HDLC protocol is shown below :
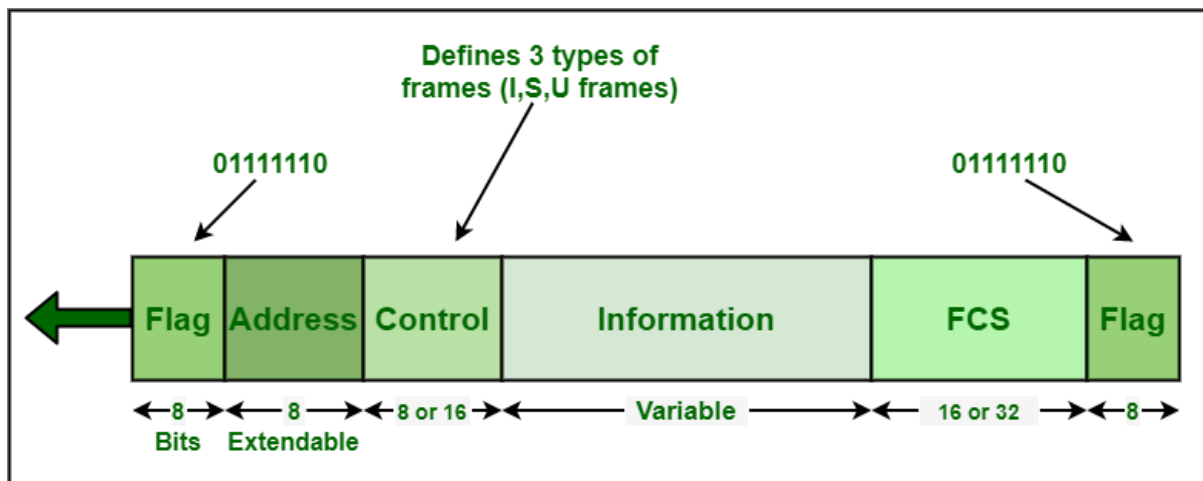

Basic Frame Structure

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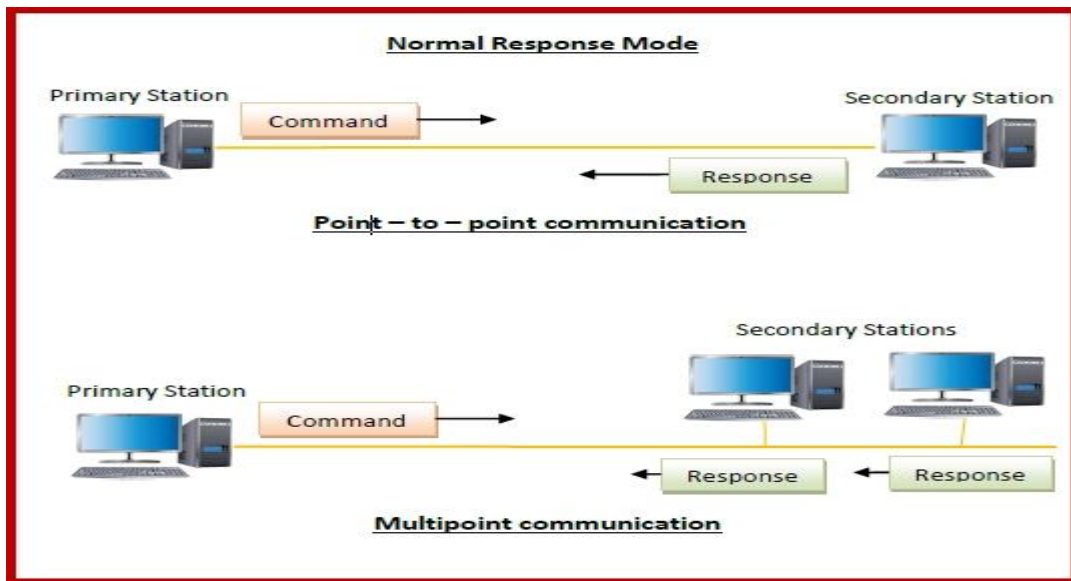
- **Asynchronous Balanced Mode (ABM)** – Here, the configuration is balanced, i.e. each station can both send commands and respond to commands. It is used for only point - to - point communications.
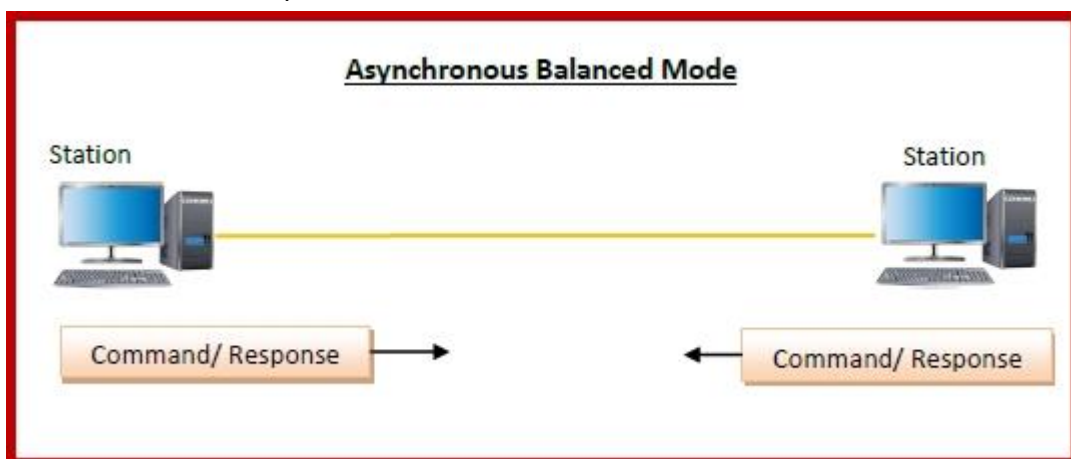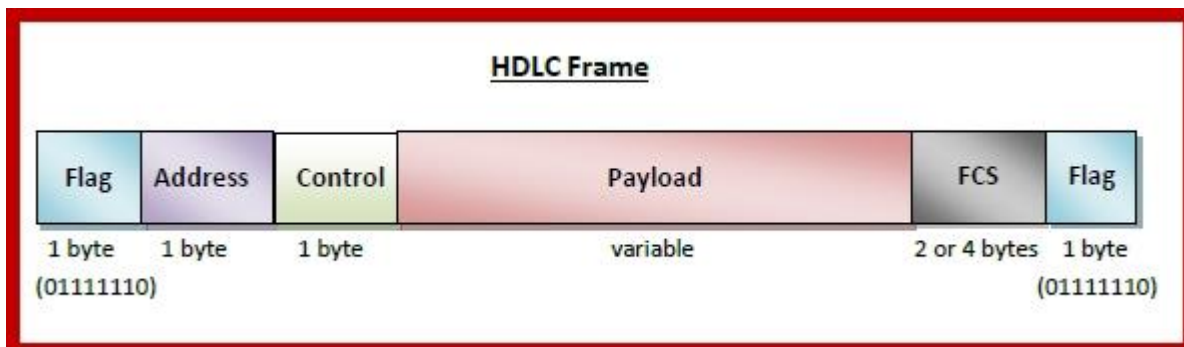

HDLC Frame

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)
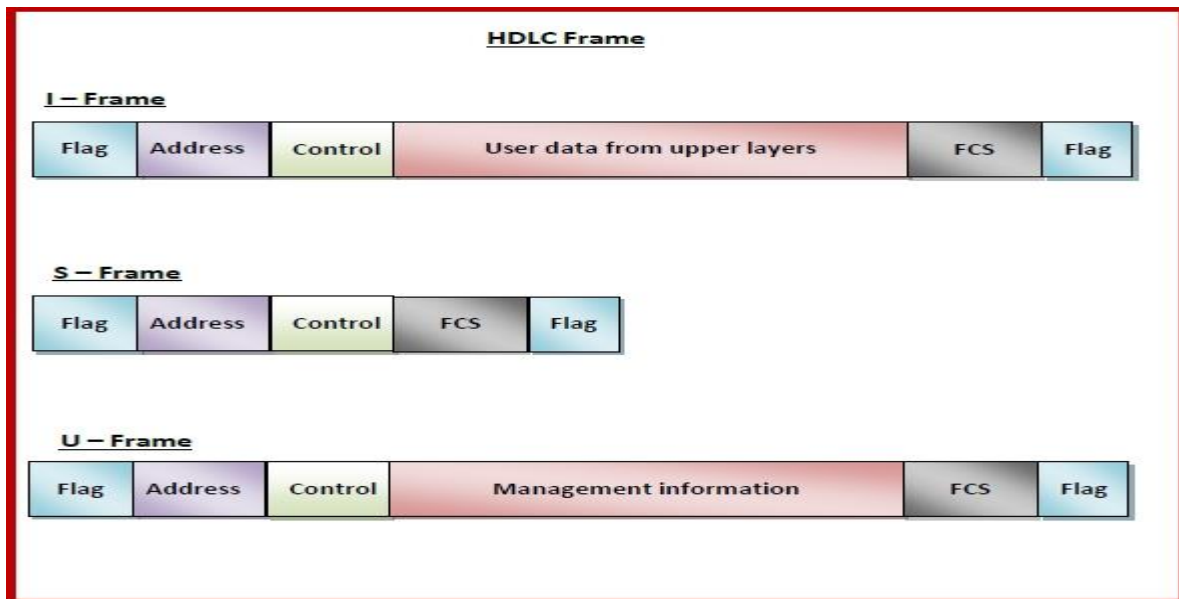

Types of HDLC Frames

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.

HDLC Frame

I – Frame

| Flag | Address | Control | User data from upper layers | FCS | Flag |

S – Frame

| Flag | Address | Control | FCS | Flag |

U – Frame

| Flag | Address | Control | Management information | FCS | Flag |

Services provided by PPP

- ○ It defines the format of frames through which the transmission occurs.
- ○ It defines the link establishment process. If user establishes a link with a server, then "how this link establishes" is done by the PPP protocol.
- ○ It defines data exchange process, i.e., how data will be exchanged, the rate of the exchange.
- ○ The main feature of the PPP protocol is the encapsulation. It defines how network layer data and information in the payload are encapsulated in the data link frame.
- ○ It defines the authentication process between the two devices. The authentication between the two devices, handshaking and how the password will be exchanged between two devices are decided by the PPP protocol.

Services Not provided by the PPP protocol

- ○ It does not support flow control mechanism.
- ○ It has a very simple error control mechanism.
- ○ As PPP provides point-to-point communication, so it lacks addressing mechanism to handle frames in multipoint configuration.

It is a byte-oriented protocol as it provides the frames as a collection of bytes or characters. It is a WAN (Wide Area Network) protocol as it runs

over the internet link which means between two routers, internet is widely used.

PPP has two main uses which are given below:

- It is widely used in broadband communications having heavy loads and high speed. For example, an internet operates on heavy load and high speed.
- It is used to transmit the multiprotocol data between the two connected (point-to-point) computers. It is mainly used in point-to-point devices, for example, routers are point-to-point devices where PPP protocol is widely used as it is a WAN protocol not a simple LAN ethernet protocol.

Multi Protocol Label Switching (MPLS)

Multi Protocol Label Switching (MPLS) is an IP packet routing technique that routes IP packet through paths via labels instead of looking at complex routing tables of routers. This feature helps in increasing the delivery rate of IP packets. MPLS uses layer 3 service i.e, Internet Protocol, and uses router as forwarding device. The traffic of different customers is separated from each other because MPLS works somewhat like VPN. It does not work like regular VPN that encrypts the data but it ensures packet from one customer cannot be received by another customer. An MPLS header is added to packet that lies between layers 2 and 3. Hence, it is also considers to be *Layer 2.5 protocol.*

MPLS Header –
The MPLS Header is 32 bit long and is divided into four parts –
1. **Label –** This field is 20 bit long and can take value b/w 0 & $2^{20} - 1$.
2. **Exp –** They are 3 bits long and used for *Quality of Service (QoS).*
3. **Bottom of stack (S) –** It is of size 1 bit. MPLS labels are stacked one over other. If there is only one label remained in MPLS header, then its value is 1 otherwise 0.
4. **Time to Live (TTL) –** It is 8 bit long and its value is decreased by one at each hop to prevent packet to get stuck in network.

Layer 2 DLL	MPLS header	Layer 3 IP

20 bits	3 bits	1 bit	8 bits
Label	Exp	BoS	TTL
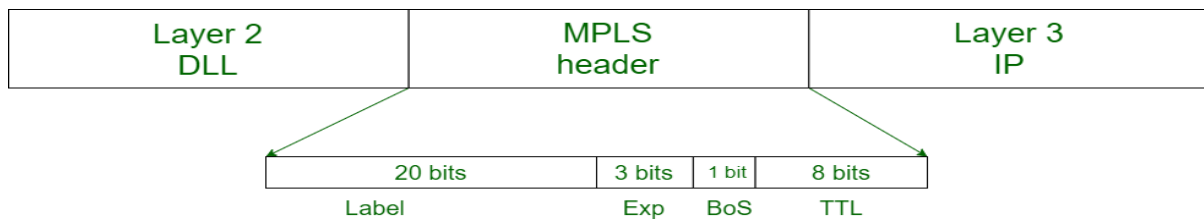
Important terms used in MPLS :

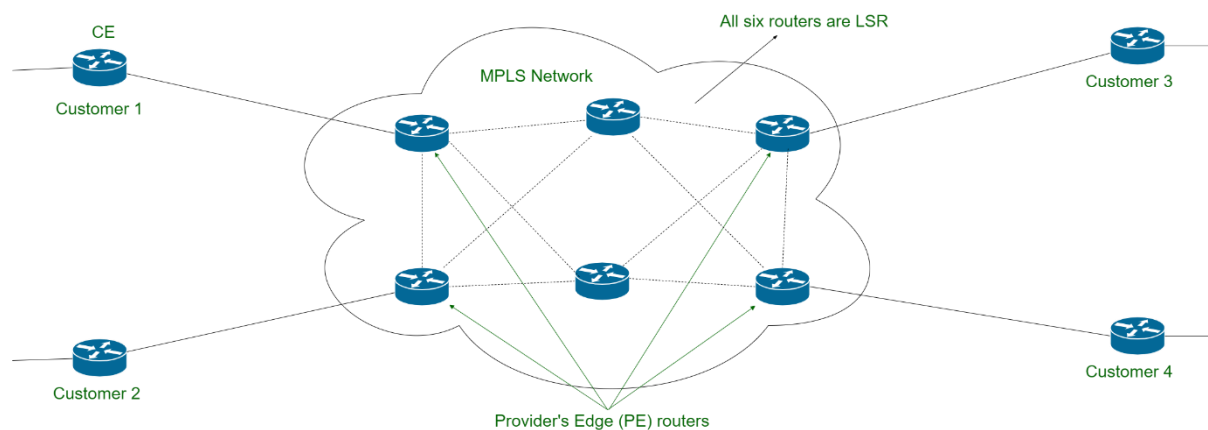| Terms	Description
Provider Edge(PE) Router	Router at edge of MPLS network that add or remove label from IP packet.
Customer Edge(CE) Router	Router at edge of customer network that send or receive IP packet from PE.
Label Switch Router(LSR)	Routers used in MPLS network that can understand labels.
Ingress LSR	LSR routers that receive IP packet from CE Routers and add MPLS header.
Intermediate LSR	LSR routers that swap label in MPLS header and assigned for forwarding labeled IP packet.
Egress LSR	LSR routers that send IP packet to CE routers and removes MPLS header.
Push, Pop and Swap	Action of addition, removal and swapping of labels by LSR respectively.

Multiprotocol Label Switching (MPLS) Routing :

Forwarding in MPLS :

LSRs receive IP packet CE and add an MPLS header in between layer 3 and layer 2 means it encapsulates the link-layer i.e, layer 2 frames. This feature allows LSRs to support receiving packets containing frames from different protocols like Frame Relay, Metro Ethernet, etc, that's why it is called multi-protocol.

MPLS forwarding is based on label attached to IP packet. This label attachment is regulated by protocol called Label Distribution Protocol(LDP). Each LSR initially learns routes as normal routers do. This learning starts with PE routers. Each PE router learns routes to different subnets from CE router. Suppose PE router PE1 learns route to subnet (say subnet1) from CE router. Now PE1 will add label to packet, forward to its neighboring LSR, and tells them that if you receive packet which destination address to subnet1 then forward it to me.

Again this process is repeated by this LSR. In this way, LSR learns routes and add this information in *Label Forwarding Information Base(LFIB)*. Now if any PE receives packet with destination to subnet1, then looking at labels and LFIB, LSRs can easily forward IP packet.

Figure – MPLS Network