UNIT-4
PART-II
5BCA_DATA COMMUNICATION

Introduction to Telephone Network

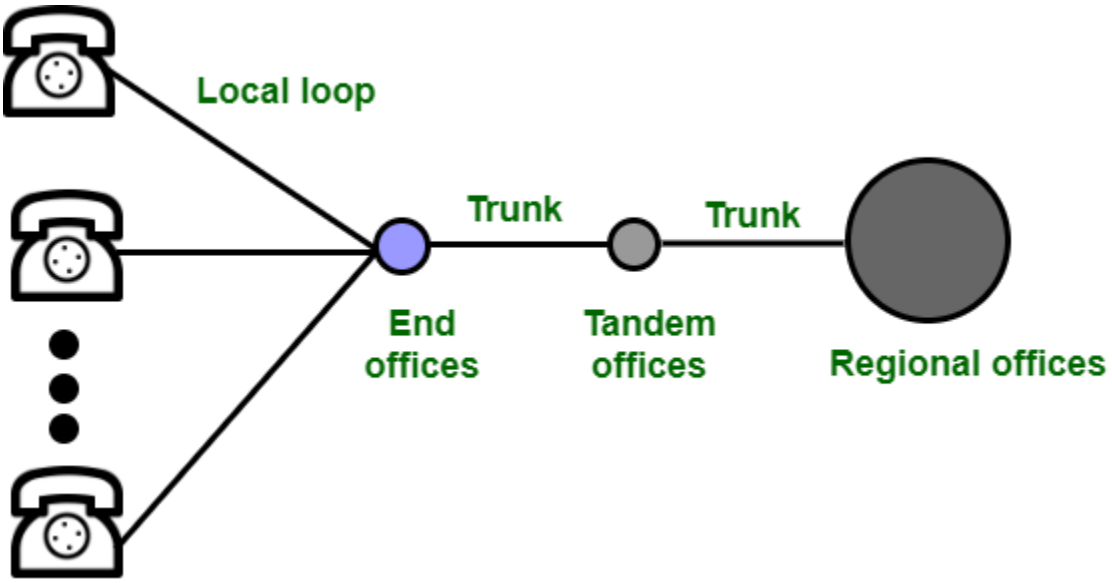
Telephone Network is used to provide voice communication. Telephone Network uses Circuit Switching. Originally, the entire network was referred to as a plain old telephone system (POTS) which uses analog signals. With the advancement of technology, i.e. in the computer era, there comes a feature to carry data in addition to voice. Today's network is both analogous and digital.

Major Components of Telephone Network:

There are three major components of the telephone network:

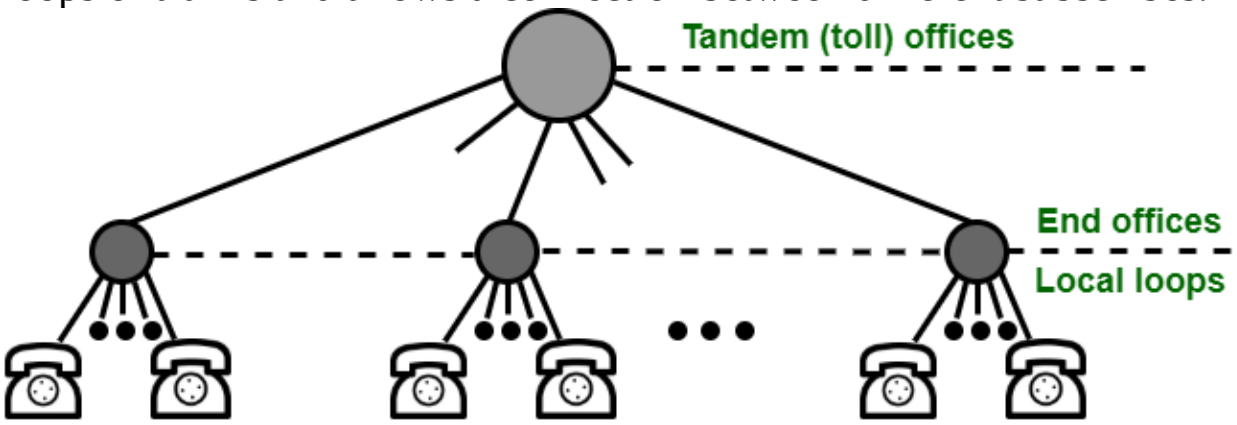
1. Local loops
2. Trunks
3. Switching Offices

There are various levels of switching offices such as end offices, tandem offices, and regional offices. The entire telephone network is as shown in the following figure:



A telephone system

Local Loops: Local Loops are the twisted pair cables that are used to connect a subscriber telephone to the nearest end office or local central office. For voice purposes, its bandwidth is 4000 Hz. It is very interesting to examine the telephone number that is associated with each local loop. The office is defined by the first three digits and the local loop number is defined by the next four digits defines.
Trunks: It is a type of transmission medium used to handle the communication between offices. Through multiplexing, trunks can handle hundreds or thousands of connections. Mainly transmission is performed through optical fibers or satellite links.
Switching Offices: As there is a permanent physical link between any two subscribers. To avoid this, the telephone company uses switches that are located in switching offices. A switch is able to connect various loops or trunks and allows a connection between different subscribes.



Switching offices

Advantages of Telephone Network:

- It is a circuit-switched network.
- There is no transmission delay as any receiver can be selected.
- It is cheap in price because it is a widely spread network.

Disadvantages of Telephone Network:

- It requires a large time for connection.
- It has a low transmission speed.

Applications of Telephone Network:

- It helps to connect people.
- It is used by business organizations to advertise their products.

- It is also used around the world for recreational purposes.

Understanding the Telecommunications Layers of the Standard Model

LATA, or “local access transport area,” in United States telephone system terminology, refers to the specific geographical coverage areas created from the breakup of AT&T into the seven regional “Baby Bells” in 1984.

Intra-LATA Layer

As its name suggests, the Intra-LATA layer takes care of telecommunication between two parties residing in a single LATA. In the U.S., a LATA is the geographical area where a Regional Bell Operating Company (RBOC) controls all the exchange of telecommunications and other access services. As the communication within the LATA is controlled by a regional company, it makes the process relatively simpler. Intra-LATA calls are confined within the single LATA so only the local exchange carrier is used for Intra-LATA calls, which are of two types: local calls and local toll (distant) calls.

Telephone sets convert audio signals to electrical signals that are transmitted to the central exchange office with the help of cables. If the calling party and receiving party both are residing in the same city coming under one LATA, the central office can connect the call to the receiver with the help of switch, which can physically connect the two parties by completing their circuit.

In case the call is made to another city that falls under the same LATA as that of caller, these calls are “local toll calls.” The call is passed on to local company “trunks” using a local exchange carrier that further connects it to switch. The switch will complete the circuit and provide an electrical signal to the receiver telephone, and the telephone will further convert the electrical signal to an audio signal for the receiver.

The Inter-LATA Layer

One Regional bell operating company can provide services in only one LATA and can’t provide its services in another LATA. So, communication between two LATAs cannot be controlled by a single RBOC. This is what differentiates inter-LATA layer from intra-LATA layer in the telecommunications model. Calls originated from one LATA and terminating in another LATA

are controlled by the inter-LATA layer of the telecommunications model. When the caller initiates a call to the distant receiver, the caller's "line card" automatically transmits the carrier represented as a four-digit code.

This four-digit code called PIC (primary interexchange carrier) code is used by the switch at the central office to route the call to another LATA through an interexchange carrier, which is usually known as IXC. The interexchange carrier is used for distant calls among two LATAs. The call is handed off to its destination, which can be identified with the help of the PIC code, by the carrier. The local telephone company, in the receiving LATA, takes care of the call and routes it to the called individual through a switch. Thus, this telecommunication layer of telecommunications model comes into the picture to provide telecommunication among two LATAs.

The Signaling Layer

When the caller initiates a call, the call is governed through the intra-LATA layer or inter-LATA layer, depending on the receiver's LATA. Then the call is established through physical circuit using switches. As the call is routed via physical or IP (internet protocol) pathways, the switch identifies the called number, with signaling switches serving the call receivers and notifying them of an incoming call. Earlier, distant calls used to take a minute or so to establish because of the involved hand-offs among different carriers. Recently with the advent of "out of band signaling," distant calls can be made in a fraction of a second. This telecommunications layer plays a key role in making call processing easier.

Crucial information like the telephone number of the caller, PIC (carrier identification code), and mode of delivery is exchanged between the switches during signaling. Advanced features like caller identification, call tracing, repeat dial, etc., provided by different telephone companies, have been made possible by signaling. Throughout the signaling process, information concerning the call is moved between two switches which streamline the phone call process.

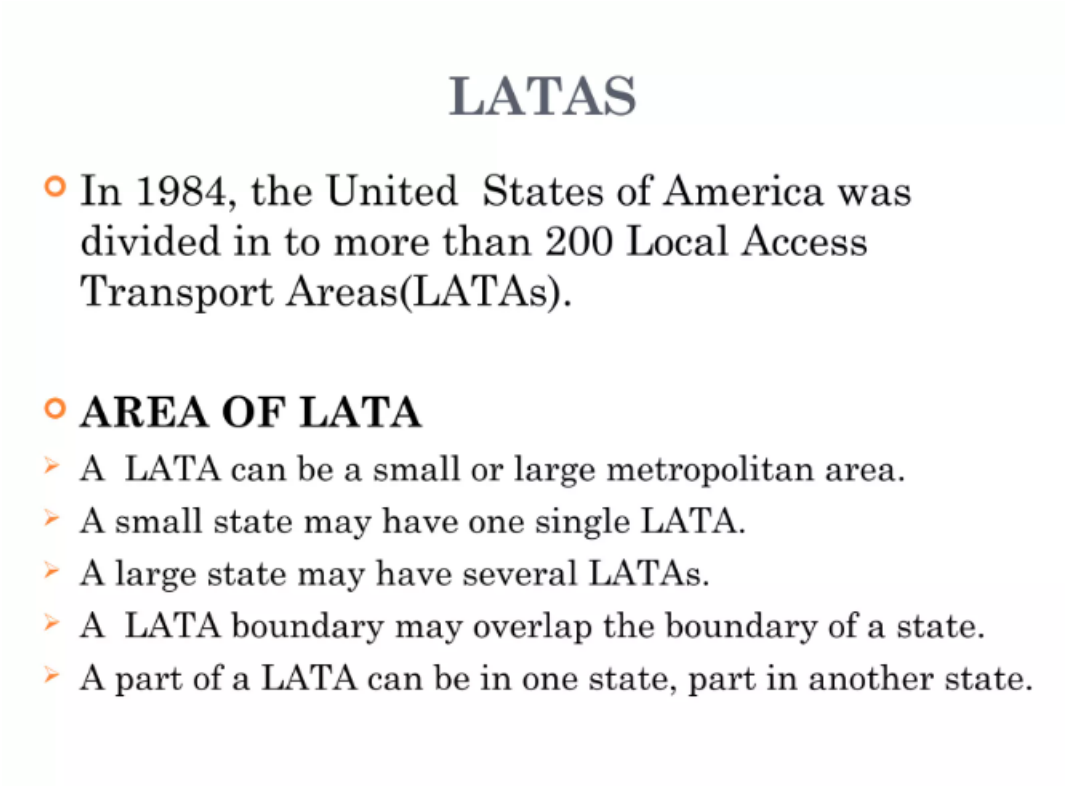
Technology has brought drastic changes from wire-dependent communication to wireless communication. With this winning more favor among the public, the signaling layers work in the same ways as wire signaling layers, but they can be modified to accommodate wireless systems.

The Billing Layer

In addition to streamlining call setup and enabling advanced features, signaling also makes billing substantially simpler. Once the call is initiated, signaling records the call setup, its route, carriers used during the call exchange (in case of inter-LATA layer), and duration of the call. All this information is saved and stored automatically. The billing layer makes use of this information to provide revenue to the telephone company. Additional chargeable services used by the caller can be tracked by the signaling layer and used by the billing layer to add to the bill of the caller.

With advances in the telecommunication model, different methods have been implemented to cope with different forms of billing that are required to be prepared for different users. The usage of SMS and MMS, for example, are among the many other services provided under the communication sector for which there must be different billing methods.

Because of the competitive market, telephone companies are offering cheaper inter-LATA calls than intra-LATA calls. This leads to confusion among consumers regarding inter-LATA and intra-LATA calls. Thus it is good for a customer to be aware of the telecommunications model and the working of the above mentioned telecommunication layers in order to make an informed decision.



INTRA LATA SERVICES

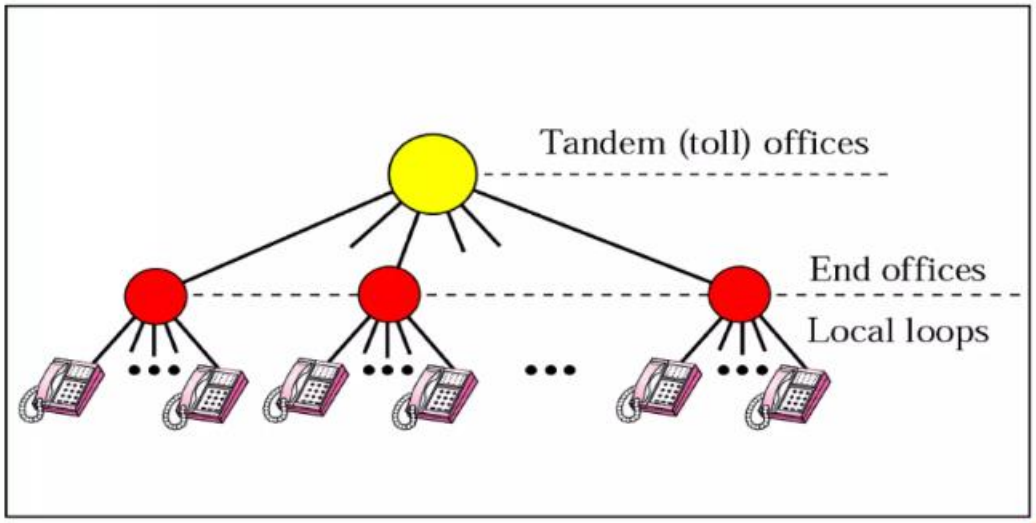
- The services offered by telephone companies inside a LATA is called intra-LATA services.
- The carrier that handles these services is called a Local Exchange Carrier(LEC).
- Before the Telecommunication act of 1996,intra lata services were granted to one single carrier.
- After 1996 more than one carrier could provide services inside a LATA.
- The carrier that provided services before 1996 owns the cabling system (Local loops) and is called the Incumbent Local Exchange Carrier(ILEC).

INTRA LATA SERVICES

- The new carriers that can provide services are called Compeitive local exchange carriers(CLECs).

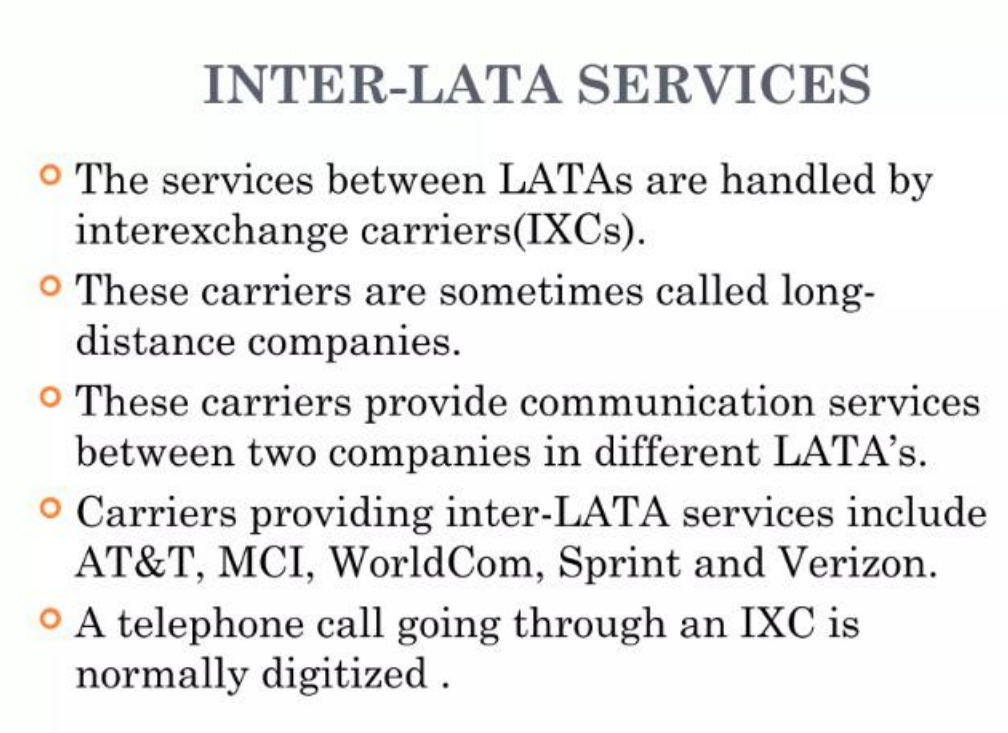
- To avoid the cost of new cabling It was agreed that ILEC's would continue to provide the main services,and the CLEC would provide other services such as mobile telephone service,toll calls inside a LATA and so on.

SWITCHING OFFICES IN A LATA



INTRA LATA SERVICES

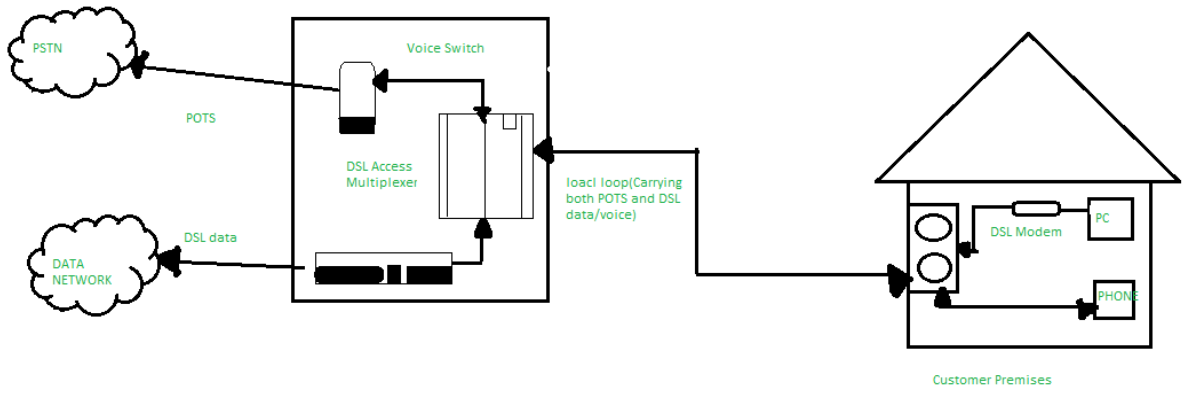
- Communication inside a LATA is handled by end switches and tandem switches.
- A call that can be completed using only end-offices is considered toll free and that has to go through a tandem office (intra-LATA toll office) is charged.



Digital Subscriber Line (DSL)

Digital Subscriber Line (DSL, *originally*, **digital subscriber loop**) is a communication medium, which is used to transfer the internet through copper wire telecommunication lines. Along with cable internet, DSL is one of the most popular ways *ISPs* provide broadband internet access.

- Its aim is to maintain the high speed of the data being transferred.
- If we ask how we going to achieve such a thing i.e., both telephone and internet facilities, then the answer is by using *splitters or DSL filters*(shown in the below diagram). Basically, the *splitter* is used to splits the frequency and make sure that they can't get interrupted.



Types of DSL are as follows:

1. **Symmetric DSL –** SDSL, *splits* the upstream and downstream frequencies evenly, providing equal speeds to both uploading and downloading data transfer. This connection may provide *2 Mbps* upstream and downstream.it is mostly preferred by small organizations.SDSL succeeded HDSL as the two-wire (single-pair) type of symmetric DSL. SDSL is also known within ANSI as HDSL2.
   Essentially offering the same capabilities as HDSL, SDSL offers T1 rates (1.544 Mbps) at ranges up to 10,000 feet and is primarily designed for business applications.

2. **Asymmetric DSL –** ADSL, provides a wider frequency range for downstream transfers, which offers several times faster downstream speeds. an ADSL connection may offer *20 Mbps downstream and 1.5 Mbps upstream*, it is because most users download more data than they upload. ADSL provides transmission speeds ranging from downstream/upstream rates of 9 Mbps/640 kbps over a relatively short distance to 1.544 Mbps/16 kbps as far as 18,000 feet. The former speeds are more suited to a business, the latter more to the computing needs of a residential customer.
3. **HDSL (High-Bit-Rate DSL)**
   Standardized in 1994, HDSL uses two pairs of 24 AWG copper wires to provide symmetric E1/T1 data rates to distances up to

3657 meters. Its successors are HDSL2 and HDSL4, the latter using four pairs of wire instead of two.

4. **VDSL: Very-High-Bit-Rate DSL**
   Also approved in 2001, VDSL as a DSL service enables downstream/upstream rates up to 52 Mbps/16 Mbps. Extenders for local networks boast 100-Mbps/60-Mbps speeds when communicating at distances up to 500 feet (152.4 m) over a single voice-grade twisted pair. As a broadband solution, VDSL enables the simultaneous transmission of voice, data, and video, including HDTV, video on demand and high-quality video conferencing. Depending on the application, you can set VDSL to run symmetrically or asymmetrically.
   VDSL2: Very-High-Bit-Rate DSL 2
   Standardized in 2006, VDSL2 provides higher bandwidth (up to 100 Mbps) and higher symmetrical speeds than VDSL, enabling its use for Triple Play services (data, video, voice) at longer distances. While VDSL2 supports upstream/downstream rates similar to VDSL, at longer distances, the speeds don't deteriorate as much as those transmitted with ordinary VDSL equipment.

Features of DSL include:

- **Speed:** DSL provides high-speed internet connectivity that is much faster than traditional dial-up connections. With DSL, users can expect download speeds of up to 25 Mbps and upload speeds of up to 3 Mbps, depending on the type of DSL service and the distance from the service provider.
- **Availability:** DSL is widely available in many areas and is often the most accessible high-speed internet option for users who live in rural or remote areas. As long as there is a telephone line, DSL can be provided, making it an attractive option for users who don’t have access to cable or fiber internet.
- **Security:** DSL provides a secure connection, as the data transmitted over the telephone lines is encrypted. This means

that hackers and other unauthorized users cannot intercept or access the data being transmitted.

- **Reliability:** DSL is a reliable internet connection option, as the connection is always on and doesn't require users to dial in or connect manually. This makes it ideal for users who need a constant internet connection for work or other purposes.
- **Affordability:** DSL is generally more affordable than other high-speed internet options, such as cable or fiber internet. This makes it an attractive option for users who need high-speed internet but don't want to pay the high prices associated with other options.
- **Compatibility**: DSL is compatible with a wide range of devices, including computers, smartphones, tablets, and other internet-connected devices. This makes it easy for users to connect to the internet and access online services and applications.

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.
- **High-speed**: DSL provides high-speed internet access, allowing users to stream, download, and upload large amounts of data quickly.
- **Simultaneous use**: DSL allows users to make voice calls and use the internet at the same time, making it a convenient option for households with multiple users who need to use the internet and the telephone at the same time.

- **Reliable**: DSL is a stable and reliable technology that provides consistent performance, making it a dependable option for internet access.
- **No data caps**: Unlike some other internet technologies, DSL doesn't have data caps, allowing users to stream, download, and upload as much data as they need without worrying about additional charges or throttled speeds.
- **Easy setup**: DSL is easy to set up and doesn't require any special equipment, making it a straightforward option for people who are new to the internet or need to get online quickly.
- **Supports multiple devices**: DSL can support multiple devices simultaneously, making it an ideal option for households with multiple users and devices.

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.

Features of DSL:

- **High-speed internet:** DSL technology provides high-speed internet access that can be up to 25 times faster than a dial-up connection.
- **Simultaneous voice and data transmission:** DSL technology allows for simultaneous voice and data transmission over the same line, so users can make phone calls and use the internet at the same time.
- **Dedicated connection:** DSL provides a dedicated connection, which means users do not have to share bandwidth with other users.
- **Distance limitations:** DSL has distance limitations, and the speed of the connection can decrease as the distance from the central office increases.
- **Different types of DSL:** There are different types of DSL, including Asymmetric DSL (ADSL), Symmetric DSL (SDSL),

and Very High Bitrate DSL (VDSL), each with different features and capabilities.

- **Availability:** DSL technology is widely available and can be used in areas where other high-speed internet options are not available.
- **Installation:** DSL requires a modem to be installed at the user's premises and a DSLAM (Digital Subscriber Line Access Multiplexer) to be installed at the telephone company's central office.
- **Cost:** DSL is typically less expensive than other high-speed internet options, such as cable or fiber-optic connections.
- **Security:** DSL provides a more secure connection than a dial-up connection because it is always on and does not require users to dial in to access the internet.
- **Dedicated bandwidth:** DSL provides users with dedicated bandwidth, which means that the speed of their internet connection is not affected by the number of users sharing the same network. This is in contrast to cable or fiber internet, where users often experience slower speeds during peak usage times.
- **Static IP addresses:** DSL providers often offer static IP addresses to their customers, which can be useful for businesses or individuals who need to host websites or run servers. A static IP address makes it easier for other users to find your website or connect to your server.
- **Easy installation:** DSL is relatively easy to install, as it only requires a telephone line and a DSL modem. Users can often install the modem themselves or with the help of their service provider, which can save time and money compared to other high-speed internet options that require professional installation.
- **Voice and data services:** Some DSL providers offer bundled packages that include both internet and phone services, allowing users to save money on their monthly bills. This can be especially convenient for users who need both services and want to manage them through a single provider.

- **Distance tolerant:** While the speed of DSL varies depending on the distance between the user and the service provider, it is generally more tolerant of longer distances than cable or fiber internet. This makes it a viable option for users who live in areas with limited high-speed internet options.

Disadvantages:

- **Distance limitations:** As mentioned earlier, the speed of the DSL connection decreases as the distance from the central office increases. This can limit the availability of high-speed internet in rural areas or in places with a large distance from the central office.
- **Speed inconsistencies:** The speed of the DSL connection can vary depending on the quality of the copper telephone lines, the distance from the central office, and the number of users connected to the network at the same time. This can lead to inconsistent speed and performance.
- **Limited bandwidth:** DSL technology provides limited bandwidth, which means that it may not be suitable for heavy data usage or for households with multiple users who require high-speed internet simultaneously.
- **Dependence on telephone lines:** DSL technology is dependent on copper telephone lines, which can be prone to interference from other devices, such as microwaves, televisions, or other electronic devices.
- **Installation limitations:** DSL technology requires the installation of a modem and a DSLAM at the central office, which can be costly and time-consuming for service providers. It may also require additional wiring and infrastructure, which can be difficult in some areas.
- **Security concerns:** DSL connections may be vulnerable to hacking or other security breaches, just like any other internet connection. Users need to take proper security measures to protect their devices and data.

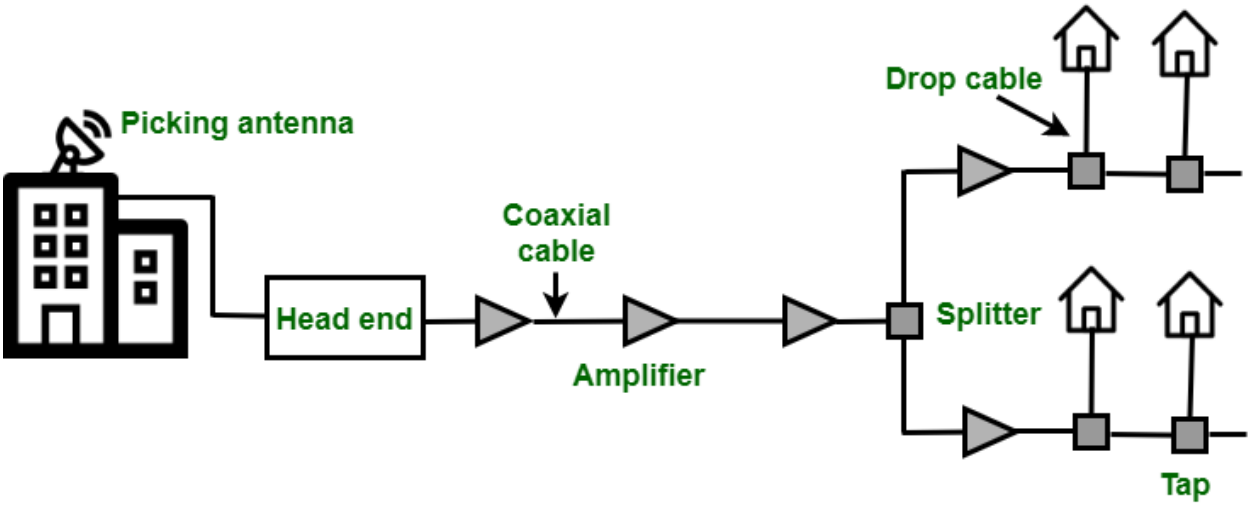
- **Availability of service providers:** DSL services are provided by telephone companies, and in some areas, there may be limited options for service providers. This can limit the ability of users to choose the best service provider or the best plan for their needs

Cable TV Networks

Cable TV network started its business only as a video service provider, but with the new advancement in technology, it's moved to the business of Internet access. It also refers to the system that distributes Television signals with the utilization of transmission media. Types of Cable TV Networks are as follows –

1. Traditionally Cable Networks
2. Hybrid Fiber-Coaxial Network

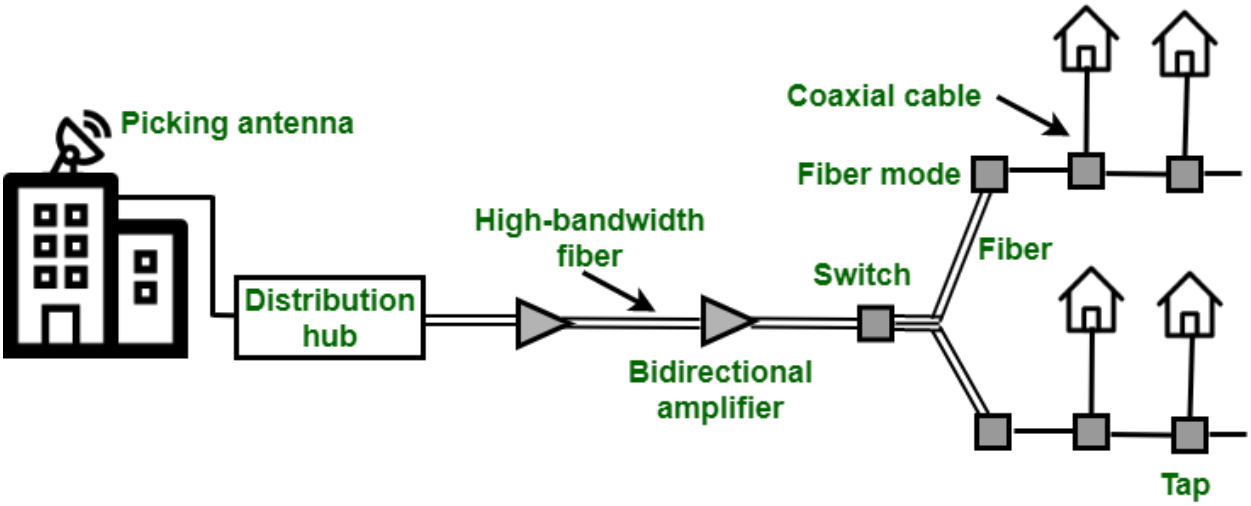
Traditional Cable Network: This network began to distribute the broadcast video signals to the locations with poor or no reception. Traditional Cable Network also called community antenna TV because this antenna is present at the highest of the building to receive signals from the TV stations then distribute these signals via coaxial cables to the community. The following is the schematic diagram of the traditional cable TV network.



Traditional cable TV network

In this, Cable TV office is referred to as the head end which can receive the video signals from broadcasting stations and then feeds the signals into coaxial cables. Due to the distance increases, the signals are getting weaker, for this purpose amplifiers were installed through this network to regenerate the signals. During this network, we have more than 35 amplifiers between the head end and the premises of subscribers. At the other end of the Cable TV network, splitters were placed to split the signal and the tap and drop cables make the connections to the subscriber premises. Communication in this network is unidirectional. The video signals were transmitted downstream from the head end to the subscriber premises.

Hybrid Fiber-Coaxial Network: Hybrid Fiber-Coaxial Network is that the second generation of the cable network. which is a combination of fiber-optic and coaxial cable is used in this type of network. The transmission mode is used is fiber node i.e. fiber mode. The schematic diagram of the HFC network is as follows –



Hybrid Fiber-Coaxial Network

There are nearly 400, 000 subscribers served by **Regional Cable Head (RCH)**. Modulation and demodulation of the signal are done through the **distribution hubs** after these signals are sent to the fiber nodes through fiber-optic cables. The fiber node split the analog signal so that the same signal is sent to each coaxial cable. Approx. 1000 subscribers are served by coaxial cable. Communication in this is bidirectional.

Advantages of Cable TV Network:

- Cable TV is stable in its service.
- It is fairly inexpensive.

Disadvantages of Cable TV Network:

- Due to the supply of single provider, it creates monopoly.
- It will cause to less privacy, when out TV cable it connected to the internet or world wide web.