INDEX

1 OPTICAL FIBER COMMUNICATION

1.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Fiber-Optic Applications
- Basic optical fiber communication system:
- The Structure of an Optical Fiber
- Principle of Operation – Theory

1.2 INTRODUCTION

The use of light for transmitting information from one place to another place is a very old technique. In 800 BC., the Greeks used fire and smoke signals for sending information like victory in a war, alerting against enemy, call for help, etc. Mostly only one type of signal was conveyed. During the second century B.C. optical signals were encoded using signaling lamps so that any message could be sent. There was no development in optical communication till the end of the 18th century. The speed of the optical communication link was limited due to the requirement of line of sight transmission paths, the human eye as the receiver and unreliable nature of transmission paths affected by atmospheric effects such as fog and rain.

In the late 19th and early 20th centuries, light was guided through bent glass rods to illuminate body cavities. Alexander Graham Bell invented a 'Photophone' to transmit voice signals over an optical beam. By 1964, a critical and theoretical specification was identified by Dr. Charles K. Kao for long-range communication devices, the 10 or 20 dB of light loss per kilometer standard. Dr. Kao also illustrated the need for a purer form of glass to help reduce light loss. By 1970 Corning Glass invented fiber-optic wire or "optical waveguide fibers" which was capable of carrying 65,000 times more information than copper wire, through which information carried by a pattern of light waves could be decoded at a destination even a thousand miles away. Corning Glass developed fiber with loss of 17 dB/ km at 633 nm by doping titanium into the fiber core. By June of 1972, multimode germanium-doped fiber had developed with a loss of 4 dB per kilometer and much greater strength than titanium-doped fiber.

In April 1977, General Telephone and Electronics tested and deployed the world's first live telephone traffic through a fiber-optic system running at 6 Mbps, in Long Beach, California. They were soon followed by Bell in May 1977, with an optical telephone communication system installed in the downtown Chicago area, covering a distance of 1.5 miles (2.4 kilometers). Each optical-fiber pair carried the equivalent of 672 voice channels. Today more than 80 percent of the world's long-distance voice and data traffic is carried over optical-fiber cables.

An **optical fiber** is a thin, flexible, transparent fiber that acts as a waveguide, or "light pipe", to transmit light between the two ends of the fiber. Optical fibers are widely used in fiber-optic communications, which permits transmission over longer distances and at higher bandwidths (data rates) than other forms of communication. Fibers are used instead of metal

wires because signals travel along them with less loss and are also immune to electromagnetic interference.

With increase in population struggle for survival increased Its impacts on appearing in human life in many ways. There have been shortage of utilizes resources. The resources consist of materials, technology, money, human recourse, information, interconnectivity etc.

Due to consistent pressure there has been different ways of innovations in almost every stream of life. In the field of telecommunication also development are happening in the fields of client terminals access technique, aggregation technique, multiplexing technique, transport technique. There has been different access technique and different type of client terminals as per respective access technique. The basic contents were limitations of transmission media and low order multiplexing and switching. The initial transmission started with attaching information leaflet with visions. The same concept was utilized on building semaphore. That came the evolution telegraphs lines after the invention of more score in which use of guided media has got important. In this era use of open wire communications having overhead line with minimal multiplexing was the latest things. However has the requirement of reliable telecommunication has increased need was well to have proper voice communications and switching like manual, electro mechanical, fully digital involving automatic increasing order of multiplexing were implemented. In this era the main access network comprised of cable network made up of copper and transmission network was predominately of over head lines. Later on seeing the limitations of over head lines like deterioration weather due to electro magnetite interference less carrying capacity ete. were found. Use of optical fibre as a transmission media got thrust due to less cost, improve technology in multiplexing, virtually infants capacity and immunity to electro-magnetic interference. Requirement of bandwidth which was around 20Kbps have reached to around 1Gbps. The accesses network is also converging with the development of IP & MPLS technologies of dada communication. Multiplexing is also migrating in TDM, FDM to packet base statistical multiplexing. Client terminals are also converging having all capabilities of voice, video, text, web and multimedia. The network is converging to one by using architecture of Next Generation network. Applications which were accesses network depended are also becoming universally accessible and a accesses network agnostic. The human interface is also improve presentably because of manufacturing line terminal incorporating signals of sensory organs like touch, vision, mind etc. Today client terminals have improve GUI based web interface having faster processing multimedia capacity and capability to communicate to multiple secessions over multiple windows having full mobility as well as portability.

Due to competitions and rapid growth of innovation, the world are become faster and expectations of prominent service delivery are also been increased. Delay in providing services has also been reduced and overall connectivity in becoming P-P i.e. pair to pair.

1.3 FIBER-OPTIC APPLICATIONS

The use and demand for optical fiber has grown tremendously and optical-fiber applications are numerous. Telecommunication applications are widespread, ranging from global networks to desktop computers. These involve the transmission of voice, data, or video over distances of less than a meter to hundreds of kilometers, using one of a few standard fiber designs in one of several cable designs.

- Long distance communication backbones
- Inter-exchange junctions

- Video transmission
- Broadband services
- Computer data communication (LAN, WAN etc.)
- High EMI areas
- Non-communication applications (sensors etc…)

ADVANTAGES OF OPTICAL FIBER COMMUNICATION

Fiber Optics has the following advantages:

1.3.1 Wider bandwidth: The information carrying capacity of a transmission system is directly proportional to the carrier frequency of the transmitted signals. The optical carrier frequency is in the range 10^{13} to 10^{15} Hz while the radio wave frequency is about 10^{6} Hz and the microwave frequency is about 10^{10} Hz. Thus the optical fiber yields greater transmission bandwidth than the conventional communication systems and the data rate or number of bits per second is increased to a greater extent in the optical fiber communication system. Further the wavelength division multiplexing operation by the data rate or information carrying capacity of optical fibers is enhanced to many orders of magnitude.

1.3.2 Low transmission loss: Due to the usage of the ultra low loss fibers and the erbium doped silica fibers as optical amplifiers, one can achieve almost lossless transmission. In the modern optical fiber telecommunication systems, the fibers having a transmission loss of 0.2dB/km are used. Further, using erbium doped silica fibers over a short length in the transmission path at selected points; appropriate optical amplification can be achieved. Thus the repeater spacing is more than 100 km. Since the amplification is done in the optical domain itself, the distortion produced during the strengthening of the signal is almost negligible.

1.3.3 Dielectric waveguide: Optical fibers are made from silica which is an electrical insulator. Therefore they do not pickup any electromagnetic wave or any high current lightning. It is also suitable in explosive environments. Further the optical fibers are not affected by any interference originating from power cables, railway power lines and radio waves. There is no cross talk between the fibers even though there are so many fibers in a cable because of the absence of optical interference between the fibers.

1.3.4 Signal security: The transmitted signal through the fibers does not radiate. Further the signal cannot be tapped from a fiber in an easy manner. Therefore optical fiber communication provides hundred per cent signal security.

1.3.5 Small size and weight: Fiber optic cables are developed with small radii, and they are flexible, compact and lightweight. The fiber cables can be bent or twisted without damage. Further, the optical fiber cables are superior to the copper cables in terms of storage, handling, installation and transportation, maintaining comparable strength and durability.

1.4 FIBER OPTICS BASICS: PRINCIPLES OF OPTICAL COMMUNICATION

Optical Fiber is new medium, in which information (voice, Data or Video) is transmitted through a glass or plastic fiber, in the form of light, following the transmission sequence give below:

(1) Information is encoded into Electrical Signals.
(2) Electrical Signals are converted into light Signals.

(3) Light Travels down the Fiber.
(4) A Detector Changes the Light Signals into Electrical Signals.
(5) Electrical Signals are decoded into Information.

- Inexpensive light sources available.
- Repeater spacing increases along with operating speeds because low loss fibres are used at high data rates.

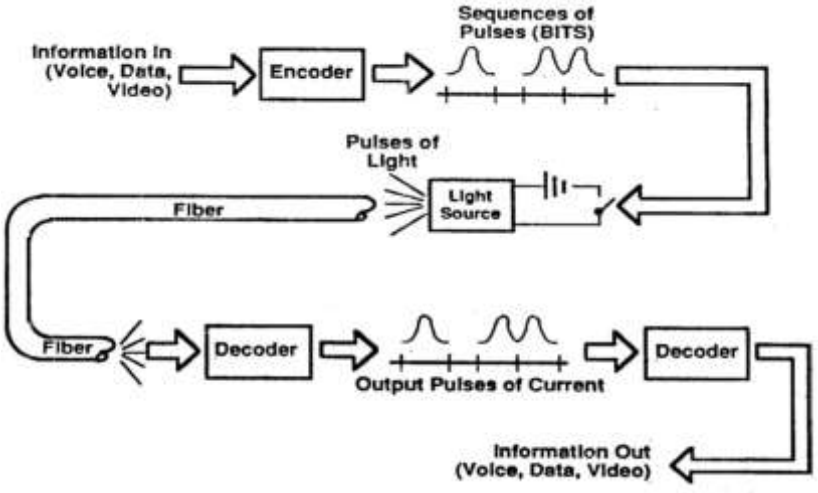

Figure 1: Fiber Optic System

1.5 PRINCIPLE OF OPERATION - THEORY

Speed of light is actually the velocity of electromagnetic energy in vacuum such as space. Light travels at slower velocities in other materials such as glass. Light travelling from one material to another changes speed, which results in changing its direction of travel. This deflection of light is called Refraction. The amount that a ray of light passing from a lower refractive index to a higher one, is bent towards the normal, but light going from a higher index to a lower one, refracting away from the normal, as shown in the figures.

The basics of light propagation can be discussed with the use of geometric optics. The basic law of light guidance is Snell's law (Fig. 2). Consider two dielectric media with different refractive indices and with n1 >n2 and that are in perfect contact, as shown in Figure. At the interface between the two dielectrics, the incident and refracted rays satisfy Snell's law of refraction—that is, $\mathbf{n1 \sin\phi 1 = n2 \sin\phi 2}$

In addition to the refracted ray there is a small amount of reflected light in the medium with refractive index n1. Because n1 >n2 then always $\boldsymbol{\phi 2 > \phi 1}$. As the angle of the incident ray increases there is an angle at which the refracted ray emerges parallel to the interface between the two dielectrics. This angle is referred to as the critical angle, ϕcrit, and from Snell's law is given by

$$\mathbf{Sin\phi crit = n2/n1}$$

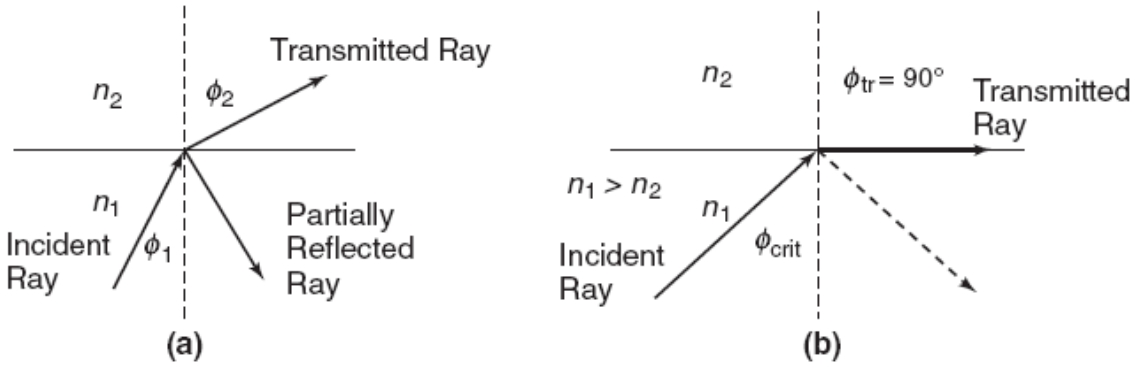

Figure 2: Snell's law

If the angle of incidence increases amore than the critical angle, the light is totally reflected back into the first material so that it does not enter the second material. The angle of incidence and reflection are equal and it is called **Total Internal Reflection**.

1.6 PROPAGATION OF LIGHT THROUGH FIBRE

The optical fiber has two concentric layers called the core and the cladding. The inner core is the light carrying part. The surrounding cladding provides the difference refractive index that allows total internal reflection of light through the core. The index of the cladding is approximately 1% lower than that of the core. Typical values for example are a core refractive index of 1.47 and a cladding index of 1.46. Fiber manufacturers control this difference to obtain desired optical fiber characteristics. Most fibers have an additional coating around the cladding. This buffer coating is a shock absorber and has no optical properties affecting the propagation of light within the fiber. Figure shows the idea of light travelling through a fiber. Light injected into the fiber and striking core to cladding interface at greater than the critical angle, reflects back into core, since the angle of incidence and reflection are equal, the reflected light will again be reflected. The light will continue zigzagging down the length of the fiber. Light striking the interface at less than the critical angle passes into the cladding, where it is lost over distance. The cladding is usually inefficient as a light carrier, and light in the cladding becomes attenuated fairly. Propagation of light through fiber is governed by the indices of the core and cladding by Snell's law.

Such total internal reflection forms the basis of light propagation through a optical fiber. This analysis consider only meridional rays- those that pass through the fiber axis each time, they are reflected. Other rays called Skew rays travel down the fiber without passing through the axis. The path of a skew ray is typically helical wrapping around and around the central axis. Fortunately skew rays are ignored in most fiber optics analysis.

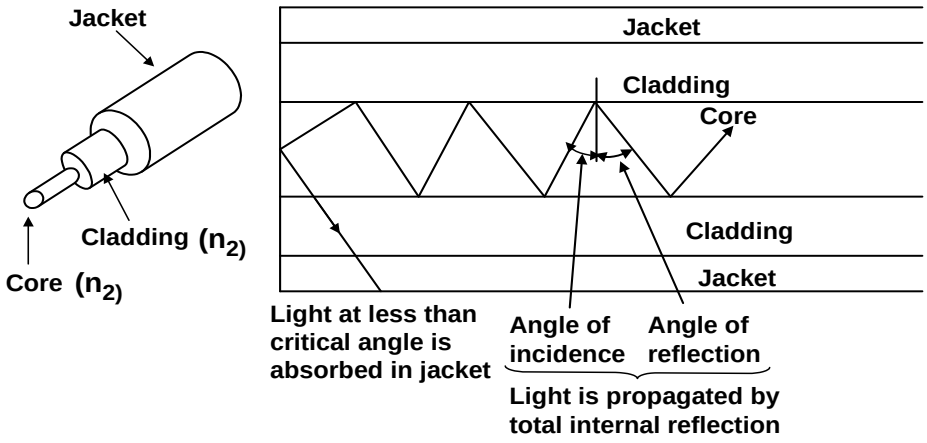

Figure 3: Propagation of light through fiber

The specific characteristics of light propagation through a fiber depends on many factors, including

- The size of the fiber.
- The composition of the fiber.

The light injected into the fiber

1.7 GEOMETRY OF FIBER

The optical fibers used in communications have a very simple structure. A hair-thin fiber consists of two concentric layers of high-purity silica glass, the core and the cladding, which are enclosed by a protective sheath as shown in Fig. given below. Core and cladding have different refractive indices, with the core having a refractive index, n1, which is slightly higher than that of the cladding, n2. It is this difference in refractive indices that enables the fiber to guide the light. Because of this guiding property, the fiber is also referred to as an "optical waveguide." As a minimum there is also a further layer known as the secondary cladding that does not participate in the propagation but gives the fiber a minimum level of protection, this second layer is referred to as a coating. Light rays modulated into digital pulses with a laser or a light-emitting diode moves along the core without penetrating the cladding.

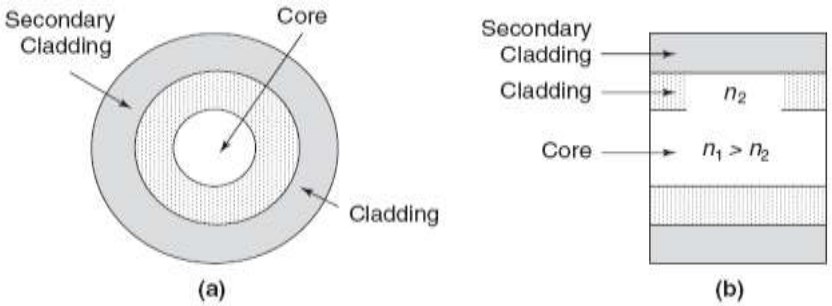

Figure 4: (a) Cross section and (b) longitudinal cross section of a typical optical fiber

The light stays confined to the core because the cladding has a lower refractive index—a measure of its ability to bend light. Refinements in optical fibers, along with the development of new lasers and diodes, may one day allow commercial fiber-optic networks to carry trillions of bits of data per second.

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Table-1The diameters of the core and cladding

Core (μm)	**Cladding (μ m)**
8	125
50	125
62.5	125
100	140

Fibre sizes are usually expressed by first giving the core size followed by the cladding size. Thus 50/125 means a core diameter of 50μm and a cladding diameter of 125μm.

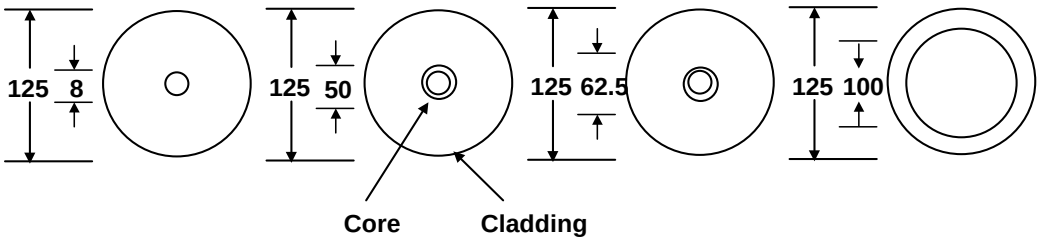


Figure 5: Typical Core and Cladding Diameter

1.8 FIBRE TYPES – SINGLE MODE AND MULTI-MODE

The refractive Index profile describes the relation between the indices of the core and cladding. Two main relationships exist:

(I) Step Index
(II) Graded Index

The step index fibre has a core with uniform index throughout. The profile shows a sharp step at the junction of the core and cladding. In contrast, the graded index has a non-uniform core. The Index is highest at the center and gradually decreases until it matches with that of the cladding. There is no sharp break in indices between the core and the cladding.

By this classification there are three types of fibres :

(I) Multimode Step Index fibre (Step Index fibre)
(II) Multimode graded Index fibre (Graded Index fibre)
(III) Single- Mode Step Index fibre (Single Mode Fibre)

1. STEP-INDEX MULTIMODE FIBER

Step Index multimode Fiber has a large core, up to 100 microns in diameter. As a result, some of the light rays that make up the digital pulse may travel a direct route, whereas others zigzag as they bounce off the cladding. These alternative pathways cause the different groupings of light rays, referred to as modes, to arrive separately at a receiving point. The pulse, an aggregate of different modes, begins to spread out, losing its well-defined shape. The need to leave spacing between pulses to prevent overlapping limits bandwidth that is, the amount of information that can be sent. Consequently, this type of fiber is best suited for transmission over short distances, in an endoscope, for instance.

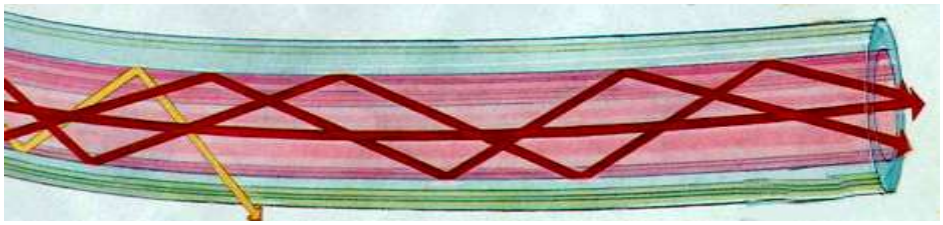


Figure 6: STEP-INDEX MULTIMODE FIBER

2. GRADED-INDEX MULTIMODE FIBER

It contains a core in which the refractive index diminishes gradually from the center axis out toward the cladding. The higher refractive index at the center makes the light rays moving down the axis advance more slowly than those near the cladding.

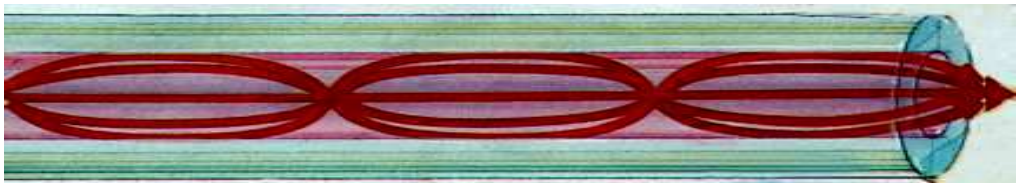


Figure 7: GRADED-INDEX MULTIMODE FIBER

Also, rather than zigzagging off the cladding, light in the core curves helically because of the graded index, reducing its travel distance. The shortened path and the higher speed allow light at the periphery to arrive at a receiver at about the same time as the slow but straight rays in the core axis. The result: a digital pulse suffers less dispersion.

3. SINGLE-MODE FIBER

It has a narrow core (nine microns or less), and the index of refraction between the core and the cladding changes less than it does for multimode fibers. Light thus travels parallel to the axis, creating little pulse dispersion. Telephone and cable television networks install millions of kilometers of this fiber every year.

Figure 8: SINGLE-MODE FIBER

CABLE CONSTRUCTION

There are two basic cable designs are:

1. Tight Buffer Tube Cable
2. Loose Buffer Tube Cable

Loose-tube cable is used in the majority of outside-plant installations and tight-buffered cable, primarily used inside buildings.

TIGHT BUFFER TUBE CABLE

With tight-buffered cable designs, the buffering material is in direct contact with the fiber. This design is suited for "jumper cables" which connect outside plant cables to terminal equipment, and also for linking various devices in a premises network. Single-fiber tight-buffered cables are used as pigtails, patch cords and jumpers to terminate loose-tube cables directly into opto-electronic transmitters, receivers and other active and passive components. Multi-fiber tight-buffered cables also are available and are used primarily for alternative routing and handling flexibility and ease within buildings. The tight-buffered design provides a rugged cable structure to protect individual fibers during handling, routing and connectorization. Yarn strength members keep the tensile load away from the fiber.

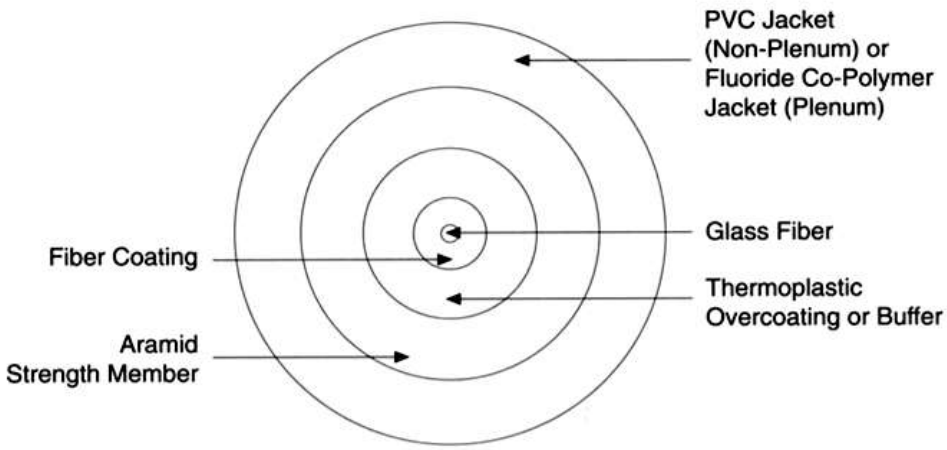


Figure 9: Tight Buffer Tube Cable

The structure of a 250um coated fiber (bare fiber)

- Core (9um for standard single mode fibers, 50um or 62.5um for multimode fibers)
- Cladding (125um)
- Coating (soft plastic, 250um is the most popular, sometimes 400um is also used)

LOOSE-TUBE CABLE

The modular design of loose-tube cables typically holds **6, 12, 24, 48, 96 or even more than 400 fibers per cable**. Loose-tube cables can be all-dielectric or optionally armored. The loose-tube design also helps in the identification and administration of fibers in the system.

In a loose-tube cable design, color-coded plastic buffer tubes house and protect optical fibers. A gel filling compound impedes water penetration. Excess fiber length (relative to buffer tube length) insulates fibers from stresses of installation and environmental

loading. Buffer tubes are stranded around a dielectric or steel central member, which serves as an anti-buckling element.

The cable core typically uses aramid yarn, as the primary tensile strength member. The outer polyethylene jacket is extruded over the core. If armoring is required, a corrugated steel tape is formed around a single jacketed cable with an additional jacket extruded over the armor. Loose-tube cables typically are used for outside-plant installation in aerial, duct and direct-buried applications.

Loose tube cable is designed to endure outside temperatures and high moisture conditions. The fibers are loosely packaged in gel filled buffer tubes to repel water. Recommended for use between buildings that are unprotected from outside elements. Loose tube cable is restricted from inside building use.

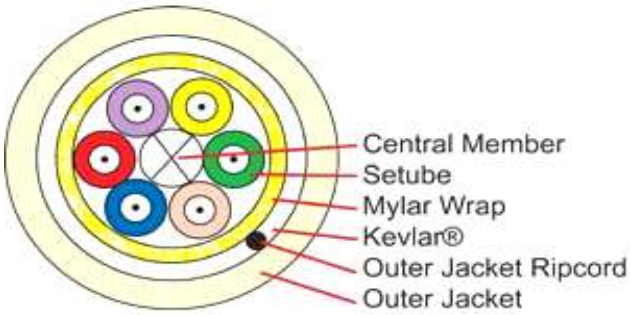


Figure 10: Loose Tube Cable

Elements in a loose tube fiber optic cable:

1. Multiple 250um coated bare fibers (in loose tube)
2. One or more loose tubes holding 250um bare fibers. Loose tubes strand around the central strength member.
3. Moisture blocking gel in each loose tube for water blocking and protection of 250um fibers
4. Central strength member (in the center of the cable and is stranded around by loose tubes)
5. Aramid Yarn as strength member
6. Ripcord (for easy removal of inner jacket)
7. Outer jacket (Polyethylene is most common for outdoor cables because of its moisture resistant, abrasion resistant and stable over wide temperature range characteristics.)

1.9 TYPES OF FIBER OPTIC CABLE (MOST POPULAR FIBER OPTIC CABLE TYPES)

1.9.1 INDOOR CABLES

1.9.1.1 Simplex Fiber Cables

A single cable structure with a single fiber. Simplex cable varieties include 1.6mm & 3mm jacket sizes.

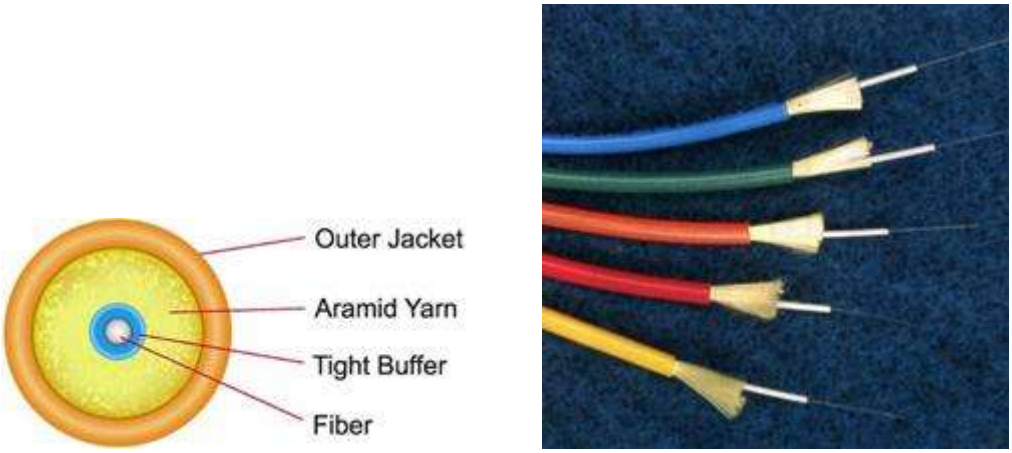


Figure 11: Simplex Fiber Cables

1.9.1.2 Duplex Fiber Optic Cable

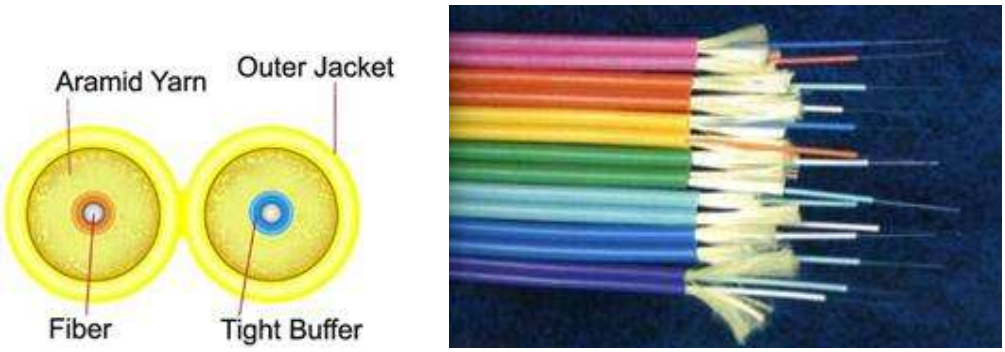


Figure 12: Duplex Fiber Optic Cable

1.9.2 OUTDOOR LOOSE TUBE FIBER OPTIC CABLES

Tube encloses multiple coated fibers that are surrounded by a gel compound that protects the cable from moisture in outside environments. Cable is restricted from indoor use, typically allowing entry not to exceed 50 feet.

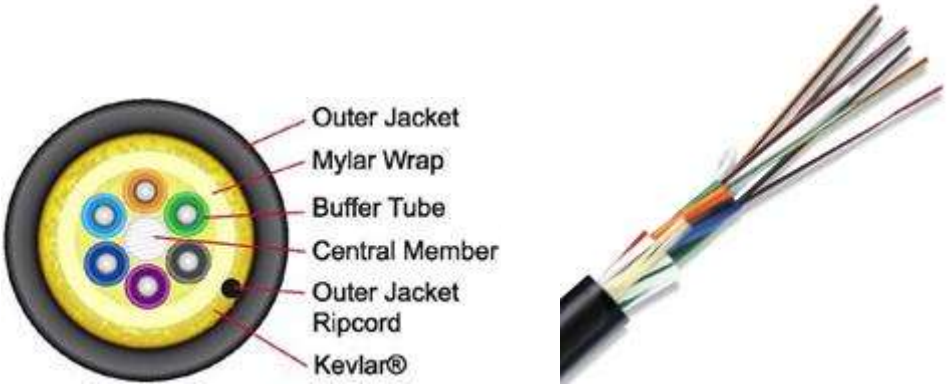


Figure 13: Outdoor Loose Tube Fiber Optic Cables

1.9.3 AERIAL/SELF-SUPPORTING

Figure 8 (aerial/self-supporting) fiber cables are designed to be strung from poles outdoors and most can also be installed in underground ducts. They have internal stress members of steel of steel or aramid yarn that protect fibers from stress.

Aerial cable provides ease of installation and reduces time and cost. Figure 8 cable can easily be separated between the fiber and the messenger. Temperature range -55 to +85°C.

Figure 14: Cable

1.9.4 DIRECT-BURIED ARMORED FIBER OPTIC CABLE

Armored cables are similar to outdoor cables but include an outer armor layer for mechanical protection and to prevent damage. They can be installed in ducts or aerially, or directly buried underground. Armor is surrounded by a polyethylene jacket.

Armored cable can be used for rodent protection in direct burial if required. This cable is non-gel filled and can also be used in aerial applications. The armor can be removed leaving the inner cable suitable for any indoor/outdoor use. Temperature rating -40 to +85°C.

Figure 15: Armored cable

1.9.5 SUBMARINE FIBER OPTIC CABLE (UNDERSEA FIBER OPTIC CABLE)

Submarine cables are used in fresh or salt water. To protect them from damage by fishing trawlers and boat anchors they have elaborately designed structures and armors. Long distance submarine cables are especially complex designed.

Figure 16: Submarine cables

ITU-T COMPLAINT FIBERS

- G.651 Multimode Fiber
- G.652 Standard Fiber
- G.653 Dispersion Shifted Fiber
- G.654 Loss minimized Fiber
- G.655 Non Zero Dispersion Shifted Fiber
- G.656 Medium Dispersion Fiber (MDF), designed for local access
- G.657 Bending Loss Insensitive Fiber

1.10 CONCLUSION

Fiber optic technology is a revolutionary technological departure from the traditional copper wires twisted-pair cable or coaxial cable. The usage of optical fiber in the telecommunications industry has grown a few decades ago. Today, many industries, particularly telecommunications, choose optical fiber over copper wire because of its ability to transmit large amounts of information at a time.

An optical fiber is a flexible filament of very clear glass capable of carrying information in the form of light. Optical fibers are hair-thin structures created by forming pre-forms, which are glass rods drawn into fine threads of glass protected by a plastic coating.

2 SDH

2.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

•Limitation of PDH signals.

•Concept of SDH.

•Multiplexing Structure of STM.

2.2 INTRODUCTION

With the introduction of PCM technology in the 1960s, communications networks were gradually converted to digital technology over the next few years. To cope with the demand for ever higher bit rates, a multiplex hierarchy called the Plesiochronous digital hierarchy (PDH) evolved. The bit rates start with the basic multiplex rate of 2 Mbit/s with further stages of 8, 34 and 140 Mbit/s. In North America and Japan, the primary rate is 1.5 Mbit/s. Hierarchy stages of 6 and 44 Mbit/s developed from this. Because of these very different developments, gateways between one network and another were very difficult and expensive to realize. PCM allows multiple use of a single line by means of digital time-domain multiplexing. The analog telephone signal is sampled at a bandwidth of 3.1 kHz, quantized and encoded and then transmitted at a bit rate of 64kbit/s. A transmission rate of 2048 kbit/s results, when 30 such coded channels are collected together into a frame along with the necessary signaling information. This so-called primary rate is used throughout the world. Only the USA, Canada and Japan use a primary rate of 1544 kbit/s, formed by combining 24 channels instead of 30. The growing demand for more bandwidth meant that more stages of multiplexing were needed throughout the world. A practically synchronous (or, to give it its proper name: plesiochronous) digital hierarchy is the result. Slight differences in timing signals mean that justification or stuffing is necessary when forming the multiplexed signals. Inserting or dropping an individual 64 kbit/s channel to or from a higher digital hierarchy requires a considerable amount of complex multiplexer equipment.

Traditionally, digital transmission systems and hierarchies have been based on multiplexing signals which are plesiochronous (running at almost the same speed). Also, various parts of the world use different hierarchies which lead to problems of international interworking; for example, between those countries using 1.544 Mbit/s systems (U.S.A. and Japan) and those using the 2.048 Mbit/s system. To recover a 64 kbit/s channel from a 140 Mbit/s PDH signal, it's necessary to demultiplex the signal all the way down to the 2 Mbit/s level before the location of the 64 kbit/s channel can be identified. PDH requires "steps" (140-34, 34-8, 8-2 demultiplex; 2-8, 8-34, 34-140 multiplex) to drop out or add an individual speech or data channel (see Figure 1A).

2.3 PLESIOCHRONOUS DIGITAL MULTIPLEXING

PDH technology (Plesiochronous Digital Hierarchy) is based on pulse code modulation (PCM). In pulse code modulation a multiple-shift usage of a transmission link is enabled by TDM (time division multiplexing). PDH technology enables with its hierarchical structures the implementation of networks with transmission capacities of up to 140 Mbit/s. In applications with cross connecting on bit-level or with a demand of special interfaces, PDH system technology is in use even today.

Traditionally, transmission systems have been asynchronous, with each terminal in the network running on its own clock. In digital systems, clocking (timing) is one of the most important considerations. Timing means using a series of repetitive pulses to keep the bit rate of the data stream constant and to indicate where the ones and zeros are located in a data stream. Because these clocks are free running and not synchronized, large variations occur in the clock rate and thus the signal bit rate.

Asynchronous multiplexing uses multiple stages; lower-rate signals are multiplexed, and extra bits are added (bit-stuffing) to account for the variations of each individual stream and combined with other bits (framing bits) to form higher-level bit rates. Then bit-stuffing is used again to produce even higher bit rates. At the higher asynchronous rate, it is impossible to access these signals without multiplexing.

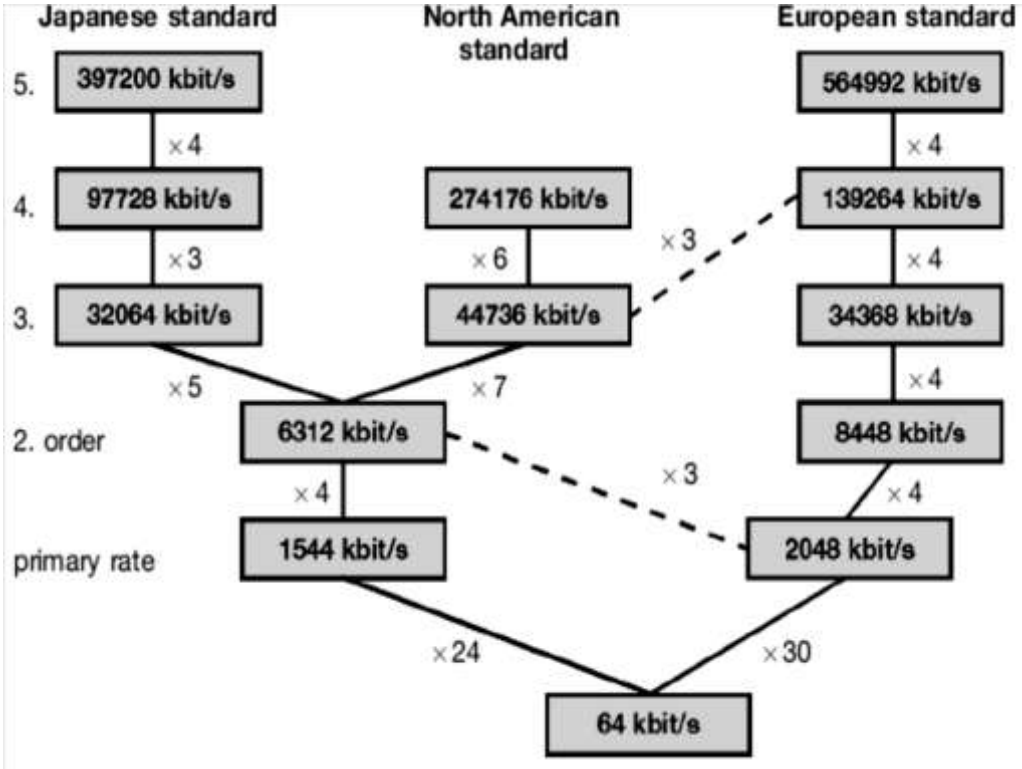


Fig. 1(A) Plesiochronous Digital Hierarchies (PDH)

The Plesiochronous Digital Hierarchy (PDH) signals have the essential characteristics of time scales or signals such that their corresponding significant instants occur at nominally the same rate. The prefix plesio, which is of Greek origin, means "almost equal but not exactly," meaning that the higher levels in the CCITT (ITU today) hierarchy are not an exact multiple of the lower level. Any variation in rate is constrained within specified limits. The PDH systems belong to the first generation of digital terrestrial telecommunication systems in commercial use.

Before SDH transmission networks were based on the PDH hierarchy. 2 Mbit/s service signals are multiplexed to 140 Mbit/s for transmission over optical fiber or radio. Multiplexing of 2 Mbit/s to 140 Mbit/s requires two intermediate multiplexing stages of 8 Mbit/s and 34 Mbit/s. Multiplexing of 2 Mbit/s to 140 Mbit/s requires multiplex equipment known as 2nd, 3rd and 4th order multiplexer.

2.4 S.D.H. EVOLUTION

SDH evolution is possible because of the following factors:

(i) **Fibre Optic Bandwidth:** The bandwidth in Optical Fibre can be increased and there is no limit for it. This gives a great advantage for using SDH.

(ii) **Technical Sophistication:** Although, SDH circuitary is highly complicated, it is possible to have such circuitary because of VLSI technique which is also very cost effective.

(iii) **Intelligence:** The availability of cheaper memory opens new possibilities.

(iv) **Customer Service Needs:** The requirement of the customer with respect to different bandwidth requirements could be easily met without much additional equipment.

The different services it supports are:

1. Low/High speed data.
2. Voice
3. Interconnection of LAN
4. Computer links
5. Broadband ISDN transport (ATM transport)

2.4.1 ADVANTAGES OF SDH

SDH brings the following advantages to network providers:

1. HIGH TRANSMISSION RATES

Transmission rates of up to 40 Gbit/s can be achieved in modern SDH systems. SDH is therefore the most suitable technology for backbones, which can be considered as being the super highways in today's telecommunications networks.

2. SIMPLIFIED ADD & DROP FUNCTION

Compared with the older PDH system, it is much easier to extract and insert low-bit rate channels from or into the high-speed bit streams in SDH. It is no longer necessary to demultiplex and then remultiplex the plesiochronous structure.

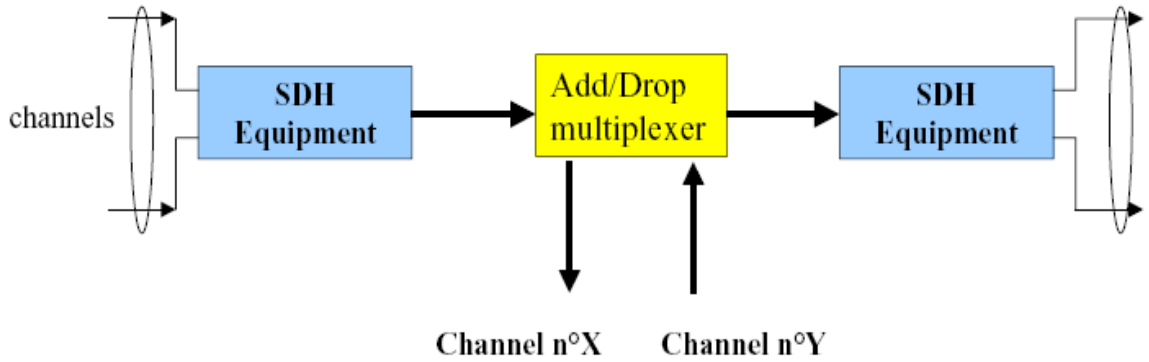


Figure 1(B): Simplified add & drop function

3. HIGH AVAILABILITY AND CAPACITY MATCHING

With SDH, network providers can react quickly and easily to the requirements of their customers. For example, leased lines can be switched in a matter of minutes. The network provider can use standardized network elements that can be controlled and monitored from a central location by means of a telecommunications network management (TMN) system.

4. RELIABILITY

Modern SDH networks include various automatic back-up and repair mechanisms to cope with system faults. Failure of a link or a network element does not lead to failure of the entire network which could be a financial disaster for the network provider. These back-up circuits are also monitored by a management system.

5. FUTURE-PROOF PLATFORM FOR NEW SERVICES

Right now, SDH is the ideal platform for services ranging from POTS, ISDN and mobile radio through to data communications (LAN, WAN, etc.), and it is able to handle the very latest services, such as video on demand and digital video broadcasting via ATM that are gradually becoming established.

6. INTERCONNECTION

SDH makes it much easier to set up gateways between different network providers and to SONET systems. The SDH interfaces are globally standardized, making it possible to combine network elements from different manufacturers into a network. The result is a reduction in equipment costs as compared with PDH.

7. SUPPORT PDH PAYLOADS

SDH supports the transmission of existing PDH payloads, other than 8Mbit/s. Most importantly, because each type of payload is transmitted in containers synchronous with the STM-1 frame, selected payloads may be inserted or extracted from the STM-1 or STM-N aggregate without the need to fully hierarchically de-multiplex as with PDH systems.

2.5 SDH RATES

SDH is a transport hierarchy based on multiples of 155.52 Mbit/s. The basic unit of SDH is STM-1. Different SDH rates are given below:

STM-1 = 155.52 Mbit/s

STM-4 = 622.08 Mbit/s

STM-16 = 2588.32 Mbit/s

STM-64 = 9953.28 Mbit/s

Each rate is an exact multiple of the lower rate therefore the hierarchy is synchronous.

2.6 THE STM-1 FRAME FORMAT

The S.D.H. standards exploit one common characteristic of all PDH networks namely 125 micro seconds duration, i.e. sampling rate of audio signals (time for 1 byte in 64 k bit per second). This is the time for one frame of SDH. The frame structure of the SDH is represented using matrix of rows in byte units as shown. As the speed increases, the number

of bits increases and the single line is insufficient to show the information on Frame structure. Therefore, this representation method is adopted. How the bits are transmitted on the line is indicated on the top of the figure.

The Frame structure contains 9 rows and number of columns depending upon synchronous transfer mode level (STM). In STM-1, there are 9 rows and 270 columns. The reason for 9 rows arranged in every 125 micro seconds is as follows:

For 1.544 Mbit PDH signal (North America and Japan Standard), there are 25 bytes in 125 micro second and for 2.048 Mbit per second signal, there are 32 bytes in 125 micro second. Taking some additional bytes for supervisory purposes, 27 bytes can be allotted for holding 1.544 Mbit per second signal, i.e. 9 rows x 3 columns. Similarly, for 2.048 Mbit per second signal, 36 bytes are allotted in 125 micro seconds, i.e. 9 rows x 4 columns. Therefore, it could be said 9 rows are matched to both hierarchies.

The standardized SDH transmission frames, called Synchronous Transport Modules of Nth hierarchical level (STM-N). The STM-1 frame is the basic transmission format for SDH. The frame lasts for 125 microseconds; therefore, there are 8000 frames per second.

A frame with a bit rate of 155.52 Mbit/s is defined in ITU-T Recommendation G.707. This frame is called the synchronous transport module (STM). Since the frame is the first level of the synchronous digital hierarchy, it is known as STM-1. Figure 4 shows the format of this frame. It is made up from a byte matrix of 9 rows and 270 columns. Transmission is row by row, starting with the byte in the upper left corner and ending with the byte in the lower right corner. The frame repetition rate is 125 ms., each byte in the payload represents a 64 kbit/s channel. The STM-1 frame is capable of transporting any PDH tributary signal.

The first 9 bytes in each of the 9 rows are called the overhead. G.707 makes a distinction between the regenerator section overhead (RSOH) and the multiplex section overhead (MSOH). The reason for this is to be able to couple the functions of certain overhead bytes to the network architecture. The table below describes the individual functions of the bytes.

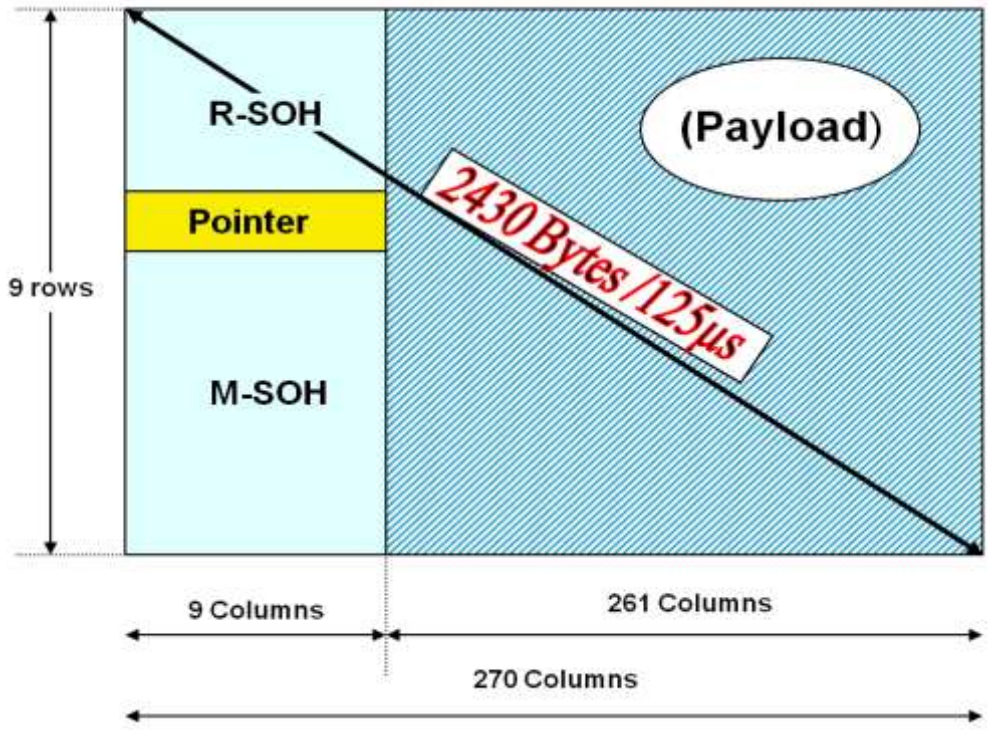


Figure 2: Schematic diagram of STM-1 frame

Calculation of Bit Rate of STM-1

- NO OF ROWS IN FRAME: 9
- NO OF COLUMNS: 270
- NO OF BYTES IN FRAME: 270*9
- NO OF BITS IN A FRAME: 270*9*8
- FRAME DURATION: 125us
- NO OF BITS TRANSMITTED IN ONE SECOND: 270*9*8*1/125 µs

=155.520Mb/S

SECTION OVERHEAD (SOH) AREA

The first 9 bytes in each of the 9 rows are called the overhead. SOH means the additional bytes in the STM-N frame structure needed for normal and flexible transmission of information payload and these bytes are mainly used for the running, management and maintenance of the network. In the 1~ 9 × N columns of the SDH frame, 1~3 rows and 5~9 rows are allocated to the SOH. SOH can be further categorized as RSOH (Regenerator Section Overhead) and MSOH (Multiplex Section Overhead). 1~3 rows are allocated to RSOH and 5~9 rows to MSOH. RSOH can be accessed either at the regenerator to at the terminal equipment. However, MSOH passes a regenerator transparently and is terminated at the terminal equipment. Fig. 3 shows distinction between the regenerator section overhead (RSOH) and the multiplex section overhead (MSOH).

STM-1 SOH

A1	A1	A1	A2	A2	A2	J0	X	X
B1	●	●	E1	●		F1	X	X
D1	●	●	D2	●		D3		
AU pointer								
B2	B2	B2	K1			K2		
D4			D5			D6		
D7			D8			D9		
D10			D11			D12		
S1					M1	E2		

X Reserved for national use

● Media-dependent use (radio-link, satellite)

Fig. 3 Section Overhead

The table below describes the individual functions of the bytes.

Table 1: Overhead bytes and their functions

Overhead byte	Function
A1, A2	Frame alignment
B1, B2	Quality monitoring, parity bytes
D1 ... D3	Q_{ECC} network management
D4 ... D12	Q_{ECC} network management
E1, E2	Voice connection
F1	Maintenance
J0 (C1)	Trace identifier
K1, K2	Automatic protection switching (APS) control
S1	Clock quality indicator
M1	Transmission error acknowledgment

PAYLOAD AREA

Information payload area is the place where information about various services is stored in the SDH frame structure. Horizontal columns 10 × N~270 × N, and vertical rows 1~9 belong to the information payload area. In it, there are still some Path Overhead (POH) bytes transmitted as part of the payload in a network and these bytes are mainly used for the monitor, management and control of the path performance.

ADMINISTRATIVE UNIT POINTER (AU-PTR) AREA

AU PTR is a kind of indicator, mainly used to indicate the accurate position of the first byte of information payload in the STM-N frame, so that the information can be correctly decomposed at the receiving end. It is located at the fourth row of 1~9 × N columns in the STM-N frame structure. The adoption of the pointer mode is an innovation of SDH. It can perform multiplex synchronization and STM-N signal frame locating in the quasi-synchronization environment.

PATH OVERHEAD

Path Overhead (POH) bytes are mainly used for the monitor, management and control of the path performance. A distinction is made between two different POH types:

VC-11/12 POH

The VC-11/12 POH is used for the low-order path. ATM signals and bit rates of 1.544 Mbit/s and 2.048 Mbit/s are transported within this path.

V5	Indication and error monitoring
J2	Path indication
N2	Tandem connection monitoring
K4	Automatic protection switching

VC-3/4 POH

The VC-3/4 POH is the high-order path overhead. This path is for transporting 140 Mbit/s, 34 Mbit/s and ATM signals.

J1	Path indication
B3	Quality monitoring
C2	Container format
G1	Transmission error acknowledgment
F2	Maintenance
H4	Superframe indication
F3	Maintenance
K3	Automatic protection switching
N1	Tandem connection monitoring

2.7 NETWORK ELEMENTS OF SDH

Figure 4 is a schematic diagram of a SDH ring structure with various tributaries. The mixture of different applications is typical of the data transported by SDH. Synchronous networks must be able to transmit plesiochronous signals and at the same time be capable of handling future services such as ATM.

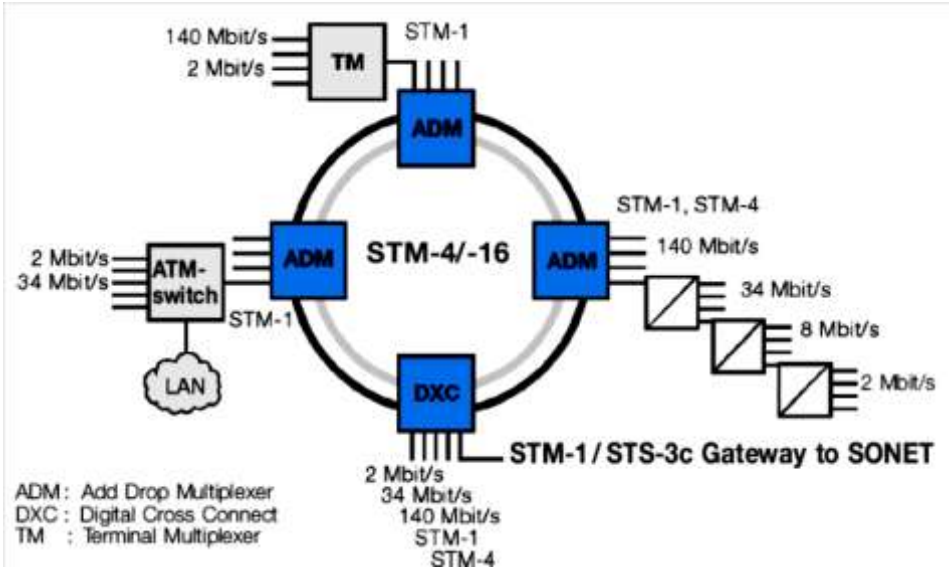


Fig. 4 Schematic diagram of hybrid communications networks

Current SDH networks are basically made up from four different types of network element. The topology (i.e. ring or mesh structure) is governed by the requirements of the network provider.

1. TERMINAL MULTIPLEXER (TM)

Terminal multiplexers are used to combine plesiochronous and synchronous input signals into higher bit rate STM–N signals as shown in Fig. 3 below. On the tributary side, all current plesiochronous bit rates can be accommodated. On the aggregate, or line side we have higher bit rate STM–N signals. Terminal multiplexers are used to combine plesiochronous and synchronous input signals into higher bit rate STM-N signals.

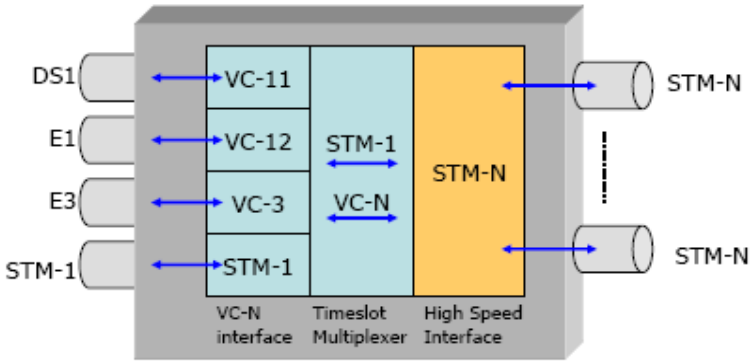


Fig.5: TM

2. ADD/DROP MULTIPLEXERS(ADM)

Add/drop multiplexers (ADM**)** permits add and drop of lower order signals. Lower bit rate synchronous signals can be extracted from or inserted into high speed SDH bit streams by means of ADMs. This feature makes it possible to set up ring structures, which have the advantage that automatic back-up path switching is possible using elements in the ring in the event of a fault.

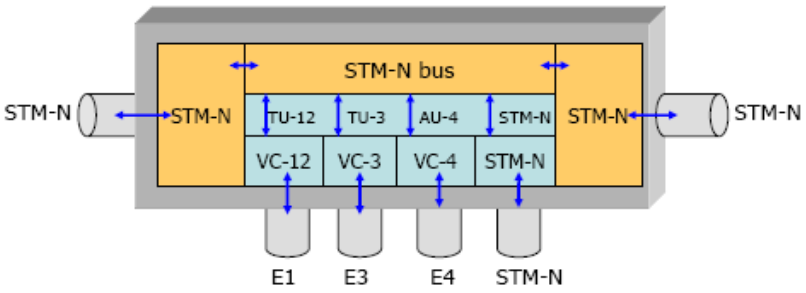


Fig. 6: ADM

3. REGENERATORS

Regenerators as the name implies, have the job of regenerating the clock and amplitude relationships of the incoming data signals that have been attenuated and distorted by dispersion. They derive their clock signals from the incoming data stream. Messages are received by extracting various 64 kbit/s channels (e.g. service channels E1, F1) in the RSOH (regenerator section overhead). Messages can also be output using these channels.

Fig. 7: Regenerator

4. DIGITAL CROSS-CONNECT (DXC)

This network element has the widest range of functions. It allows mapping of PDH tributary signals into virtual containers as well as switching of various containers up to and including VC-4. It permits switching of Transmission lines with different bit rates.

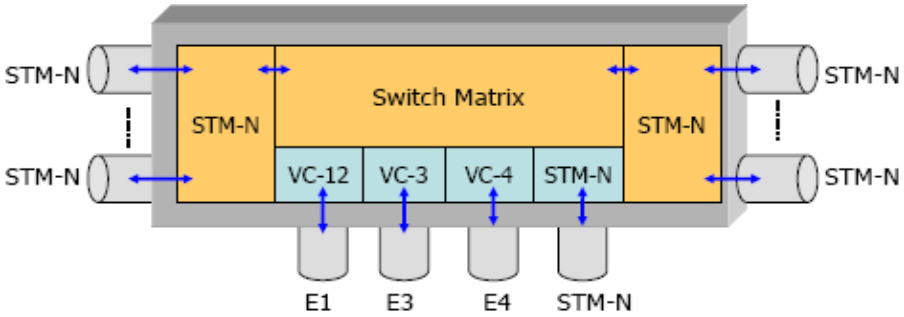


Fig.8: DXC

5. NETWORK ELEMENT MANAGER

Telecommunications management network (TMN) is considered as a further element in the synchronous network. All the SDH network elements mentioned so far are software-controlled. This means that they can be monitored and remotely controlled, one of the most important features of SDH.

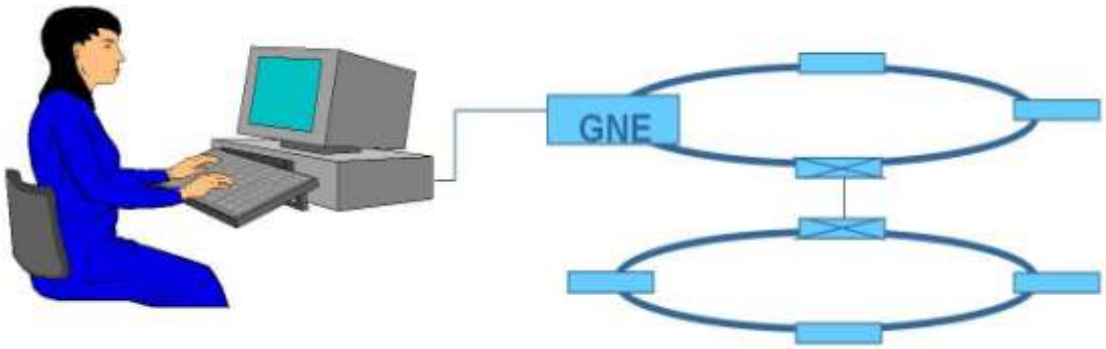


Fig.9: Network Element Manager

2.8 CONCLUSION

SDH (Synchronous Digital Hierarchy) is a standard technology for synchronous data transmission on optical media. It is the international equivalent of Synchronous Optical Network. Both technologies provide faster and less expensive network interconnection than traditional PDH (Plesiochronous Digital Hierarchy) equipment. Now Next Generation SDH is capable to support packet data also.

3 DWDM

3.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- •Concept of DWDM Technology.
- •Network Architecture of DWDM
- •Multiplexing Structure of DWDM.

3.2 INTRODUCTION

The emergence of DWDM is one of the most recent and important phenomena in the development of fiber optic transmission technology. Dense wavelength-division multiplexing (DWDM) revolutionized transmission technology by increasing the capacity signal of embedded fiber**.** One of the major issues in the networking industry today is tremendous demand for more and more bandwidth. Before the introduction of optical networks, the reduced availability of fibers became a big problem for the network providers. However, with the development of optical networks and the use of Dense Wavelength Division Multiplexing (DWDM) technology, a new and probably, a very crucial milestone is being reached in network evolution. The existing SONET/SDH network architecture is best suited for voice traffic rather than today's high-speed data traffic. To upgrade the system to handle this kind of traffic is very expensive and hence the need for the development of an intelligent all-optical network. Such a network will bring intelligence and scalability to the optical domain by combining the intelligence and functional capability of SONET/SDH, the tremendous bandwidth of DWDM and innovative networking software to spawn a variety of optical transport, switching and management related products.

3.3 DEVELOPMENT OF DWDM TECHNOLOGY

Early WDM began in the late 1980s using the two widely spaced wavelengths in the 1310 nm and 1550 nm (or 850 nm and 1310 nm) regions, sometimes called *wideband WDM*. The early 1990s saw a second generation of WDM, sometimes called *narrowband WDM*, in which two to eight channels were used. These channels were now spaced at an interval of about 400 GHz in the 1550-nm window. By the mid-1990s, dense WDM (DWDM) systems were emerging with 16 to 40 channels and spacing from 100 to 200 GHz. By the late 1990s DWDM systems had evolved to the point where they were capable of 64 to 160 parallel channels, densely packed at 50 or even 25 GHz intervals.

As fig. 1 shows, the progression of the technology can be seen as an increase in the number of wavelengths accompanied by a decrease in the spacing of the wavelengths. Along with increased density of wavelengths, systems also advanced in their flexibility of configuration, through add-drop functions, and management capabilities.

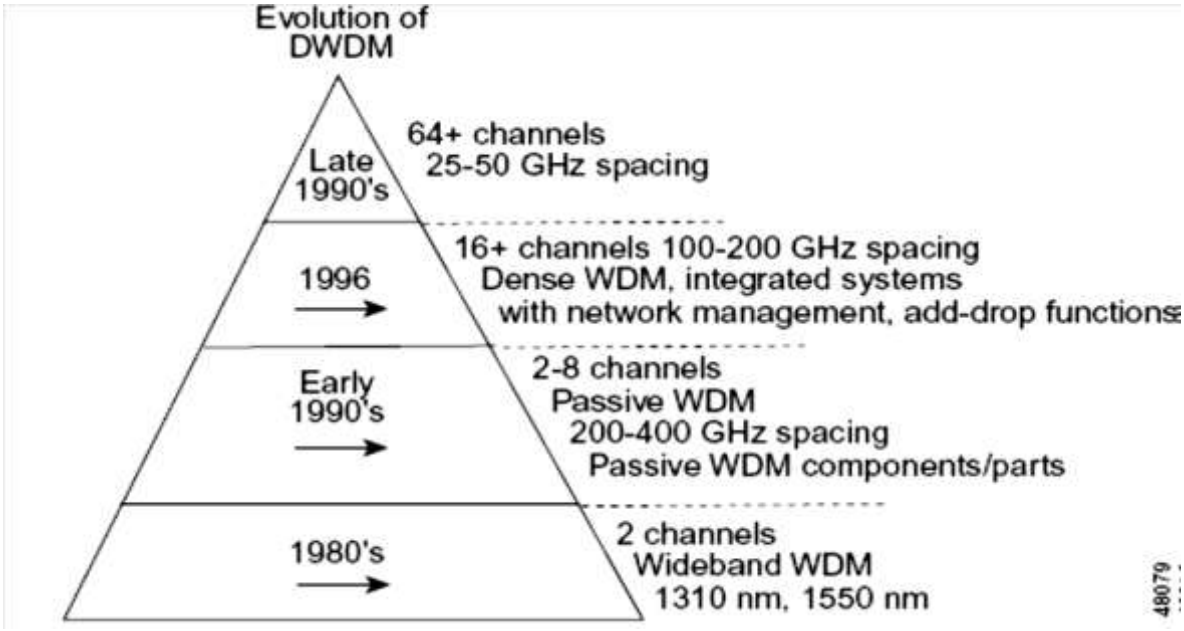


Figure 1 Evolution of DWDM

3.4 THE CHALLENGES OF TODAY'S TELECOMMUNICATIONS NETWORK

To understand the importance of DWDM and optical networking, these capabilities must be discussed in the context of the challenges faced by the telecommunications industry, and, in particular, service providers. The forecasts of the amount of bandwidth capacity needed for networks were calculated on the presumption that a given individual would only use network bandwidth six minutes of each hour. These formulas did not factor in the amount of traffic generated by Internet access (300 percent growth per year), faxes, multiple phone lines, modems, teleconferencing, and data and video transmission. In fact, today many people use the bandwidth equivalent of 180 minutes or more each hour.

Therefore, an enormous amount of bandwidth capacity is required to provide the services demanded by consumers. At the transmission speed of one Gbps, one thousand books can be transmitted per second. However today, if one million families decide they want to see video on Web sites and sample the new emerging video applications, then network transmission rates of terabits are required. With a transmission rate of one Tbps, it is possible to transmit 20 million simultaneous 2-way phone calls or transmit the text from 300 years–worth of daily newspapers per second.

In addition to this explosion in consumer demand for bandwidth, many service providers are coping with fiber exhaust in their networks. Today, many operators are nearing one hundred–percent capacity utilization across significant portions of their networks. Another problem for operators is the challenge of deploying and integrating diverse technologies in one physical infrastructure. Customer demands and competitive pressures mandate that carriers offer diverse services economically and deploy them over the embedded network. DWDM provides service providers an answer to that demand .

Use of DWDM allows providers to offer services such as e-mail, video, and multimedia carried as Internet protocol (IP) data over asynchronous transfer mode (ATM) and voice carried over SDH. Despite the fact that these format—IP, ATM, and

SDH—provide unique bandwidth management capabilities, all three can be transported over the optical layer using DWDM. This unifying capability allows the service provider the flexibility to respond to customer demands over one network.

3.5 RESOLVING THE CAPACITY CRISIS

Faced with the challenges of increased service needs, fiber exhaust, and layered bandwidth management, service providers need options to provide an economical solution. One way to alleviate fiber exhaust is to lay more fiber; this will not be the most economical solution. However, laying new fiber will not necessarily enable the service provider to provide new services or utilize the bandwidth management capability of a unifying optical layer.

A second choice is to increase the bit rate using time division multiplexing (TDM), so that more bits (data) can be transmitted per second. Traditionally, this has been the industry method of choice (STM–1, STM –4, STM –16, etc.). However, when service providers use this approach exclusively, they must make the leap to the higher bit rate in one jump, having purchased more capacity than they initially need. Based on the SDH hierarchy, the next incremental step from 10 Gbps TDM is 40 Gbps—a quantum leap that may remain unutilized in the near future.

The telecommunications industry adopted the SDH standard to provide a standard synchronous optical hierarchy with sufficient flexibility to accommodate current and future digital signals. SDH accomplishes this by defining standard rates and formats and optical interfaces. For example, multiple electrical and optical signals are brought into a SDH terminal where they are terminated and multiplexed electrically before becoming part of the payload of an STM–1, the building block frame structure of the SDH hierarchy. The STM–1 payloads are then multiplexed to be sent out on the single fiber at a single rate: STM-4 to STM-16 to STM-64 and eventually to STM-256.

A synchronous mode of transmission means that the laser signals flowing through a fiber-optic system have been synchronized to an external clock. The resulting benefit is that data streams transmitting voice, data, and images through the fiber system flow in a steady, regulated manner so that each stream of light can readily be identified and easily extracted for delivery or routing.

3.6 CAPACITY EXPANSION AND FLEXIBILITY: DWDM

The third choice for service providers is dense wavelength division multiplexing (DWDM), which increases the capacity of embedded fiber by first assigning incoming optical signals to specific frequencies (wavelength, lambda) within a designated frequency band and then multiplexing the resulting signals out onto one fiber. Because incoming signals are never terminated in the optical layer, the interface can be bit-rate and format independent, allowing the service provider to integrate DWDM technology easily with existing equipment in the network while gaining access to the untapped capacity in the embedded fiber.

DWDM combines multiple optical signals so that they can be amplified as a group and transported over a single fiber to increase capacity. Each signal carried can be at a different rate and in a different format (SDH, ATM, data, etc.) For example, a DWDM network with a mix of SDH signals operating at 2.5 Gbps and 10 Gbps over a DWDM infrastructure can achieve capacities of over 40 Gbps. A system with DWDM can achieve all this gracefully while maintaining the same degree of system performance,

reliability, and robustness as current transport systems. Today we are talking of DWDM terminals of up to 80 wavelengths of STM-16, a total of 200 Gbps, which is enough capacity to transmit 40,000 volumes of an encyclopedia in one second.

The technology that allows this high-speed, high-volume transmission is in the optical amplifier. Optical amplifiers operate in a specific band of the frequency spectrum, making it possible to boost light wave signals and thereby extend their reach without converting them back to electrical form. Demonstrations have been made of ultra wideband optical-fiber amplifiers that can boost light wave signals carrying over 100 channels (or wavelengths) of light. A network using such an amplifier could easily handle a terabit of information. At that rate, it would be possible to transmit all the world's TV channels at once or about half a million movies at the same time.

Consider a highway analogy where one fiber can be thought of as a multilane highway. Traditional TDM systems use a single lane of this highway and increase capacity by moving faster on this single lane. In optical networking, utilizing DWDM is analogous to accessing the unused lanes on the highway (increasing the number of wavelengths on the embedded fiber base) to gain access to an incredible amount of untapped capacity in the fiber. An additional benefit of optical networking is that the highway is blind to the type of traffic that travels on it. So, the vehicles on the highway can carry ATM packets, SDH, and IP.

3.7 CAPACITY EXPANSION POTENTIAL

By beginning with DWDM, service providers can establish a grow-as-you-go infrastructure, which allows them to add current and next-generation TDM systems for virtually endless capacity expansion. DWDM also gives service providers the flexibility to expand capacity in any portion of their networks—an advantage no other technology can offer. Carriers can address specific problem areas that are congested because of high capacity demands. This is especially helpful where multiple rings intersect between two nodes, resulting in fiber exhaust.

Service providers searching for new and creative ways to generate revenue while fully meeting the varying needs of their customers can benefit from a DWDM infrastructure as well. By partitioning and maintaining different dedicated wavelengths for different customers, for example, service providers can lease individual wavelengths—as opposed to an entire fiber—to their high-use business customers.

Compared with repeater-based applications, a DWDM infrastructure also increases the distances between network elements—a huge benefit for long-distance service providers looking to reduce their initial network investments significantly. The fiber-optic amplifier component of the DWDM system enables a service provider to save costs by taking in and amplifying optical signals without converting them to electrical signals. Furthermore, DWDM allows service providers to do it on a broad range of wavelengths in the 1.55µm region. For example, with a DWDM system multiplexing up to 16 wavelengths on a single fiber, carriers can decrease the number of amplifiers by a factor of 16 at each regenerator site. Using fewer regenerators in long-distance networks results in fewer interruptions and improved efficiency.

3.8 THE OPTICAL LAYER AS THE UNIFYING LAYER

Aside from the enormous capacity gained through optical networking, the optical layer provides the only means for carriers to integrate the diverse technologies of their

existing networks into one physical infrastructure. DWDM systems are bit-rate and format independent and can accept any combination of interface rates (e.g., synchronous, asynchronous, STM-1, STM-4, STM-16 etc) on the same fiber at the same time. If a carrier operates both ATM and SDH networks, the ATM signal does not have to be multiplexed up to the SDH rate to be carried on the DWDM network. Because the optical layer carries signals without any additional multiplexing, carriers can quickly introduce ATM or IP without deploying an overlay network.

But DWDM is just the first step on the road to full optical networking and the realization of the optical layer. The concept of an all-optical network implies that the service provider will have optical access to traffic at various nodes in the network, much like the SDH layer for SDH traffic. Optical wave-length add/drop (OADM) offers that capability, where wavelengths are added or dropped to or from a fiber, without requiring a SDH terminal. But ultimate bandwidth management flexibility will come with a cross-connect capability on the optical layer. Combined with OADM and DWDM, the optical cross-connect (OXC) will offer service providers the ability to create a flexible, high-capacity, efficient optical network with full optical bandwidth management.

3.9 KEY DWDM SYSTEM CHARACTERISTICS

There are certain key characteristics of acceptable and optimal DWDM systems. These characteristics should be in place for any DWDM system in order for carriers to realize the full potential of this technology. The following questions help determine whether a given DWDM system is satisfactory.

- Well-engineered DWDM systems offer component reliability, system availability, and system margin.
- An optical amplifier has two key elements: the optical fiber that is doped with the element erbium and the amplifier. When a pump laser is used to energize the erbium with light at a specific wavelength, the erbium acts as a gain medium that amplifies the incoming optical signal. If a connector is used rather than a splice, slight amounts of dirt on the surface may cause the connector to become damaged.
- Automatic adjustment of the optical amplifiers when channels are added or removed achieves optimal system performance. This is important because if there is just one channel on the system with high power, degradation in performance through self-phase modulation can occur. On the other hand, too little power results in not enough gain from the amplifier.
- In the 1530- to 1565-nm range, silica-based optical amplifiers with filters and fluoride-based optical amplifiers perform equally well. However, fluoride-based optical amplifiers are intrinsically more costly to implement.

It is possible to upgrade the channel capacity or wavelengths. However, for this they need either more power or additional signal-to-noise margin. For example, each time providers double the number of channels or the bit rate, 3 dB of additional signal-to-noise margin is needed.

3.10 VARIETIES OF WDM

Early WDM systems transported two or four wavelengths that were widely spaced. WDM and the "follow-on" technologies of CWDM and DWDM have evolved well beyond this early limitation.

3.10.1 WDM

Traditional, passive WDM systems are wide-spread with 2, 4, 8, 12, and 16 channel counts being the normal deployments. This technique usually has a distance limitation of less than 100 km.

3.10.2 CWDM

Today, coarse WDM (CWDM) typically uses 20-nm spacing (3000 GHz) of up to 18 channels. The CWDM Recommendation ITU-T G.694.2 provides a grid of wavelengths for target distances up to about 50 km on single mode fibers as specified in ITU-T Recommendations G.652, G.653 and G.655. The CWDM grid is made up of 18 wavelengths defined within the range 1270 nm to 1610 nm spaced by 20 nm.

3.10.3 DWDM

Dense WDM common spacing may be 200, 100, 50, or 25 GHz with channel count reaching up to 128 or more channels at distances of several thousand kilometers with amplification and regeneration along such a route.

3.11 DWDM SYSTEM FUNCTION

DWDM stands for ***D**ense **W**avelength **D**ivision **M**ultiplexing*, an optical technology used to increase Band width over existing fiber optic backbones. Dense wavelength division multiplexing systems allow many discrete transports channels by combining and transmitting multiple signals simultaneously at different wavelengths on the same fiber. In effect, one fiber is transformed into multiple virtual fibers. So, if you were to multiplex 32 STM-16 signals into one fiber, you would increase the carrying capacity of that fiber from 2.5 Gb/s to 80 Gb/s. Currently, because of DWDM, single fibers have been able to transmit data at speeds up to 400Gb/s.

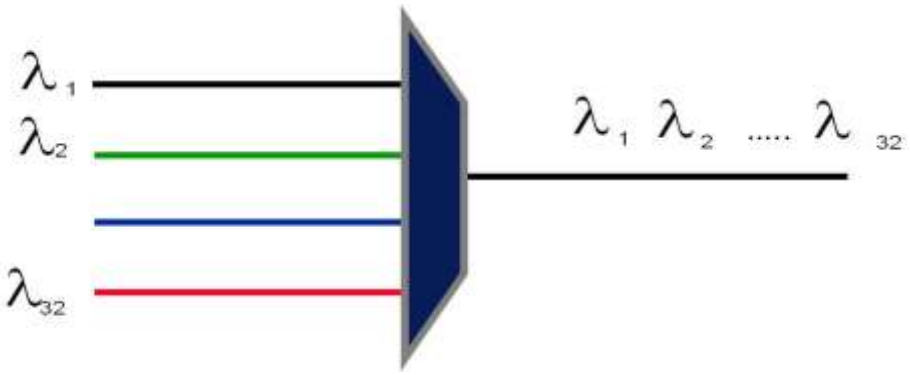


Fig. 2 Block Diagram of a DWDM System

A key advantage to DWDM is that it's protocol and bit rate-independent. DWDM-based networks can transmit data in SDH, IP, ATM and Ethernet etc. Therefore, DWDM-based networks can carry different types of traffic at different speeds over an optical channel. DWDM is a core technology in an optical transport network. Dense WDM common spacing may be 200, 100, 50, or 25 GHz with channel count reaching up to 128 or more channels at distances of several thousand kilometers with amplification and regeneration along such a route.

The concepts of optical fiber transmission, loss control, packet switching, network topology and synchronization play a major role in deciding the throughput of the network.

3.12 TRANSMISSION WINDOWS

Today, usually the second transmission window (around 1300 nm) and the third and fourth transmission windows from 1530 to 1565 nm (also called conventional band) and from 1565 to 1620 nm (also called Long Band) are used. Technological reasons limit DWDM applications at the moment to the third and fourth window.

The losses caused by the physical effects on the signal due by the type of materials used to produce fibres limit the usable wavelengths to between 1280 nm and 1650 nm. Within this usable range the techniques used to produce the fibres can cause particular wavelengths to have more loss so we avoid the use of these wavelengths as well.

3.13 DWDM SYSTEM COMPONENTS

Figure 3 shows an optical network using DWDM techniques that consists of five main components:

3.13.1 TRANSMITTER (TRANSMIT TRANSPONDER):

- Changes electrical bits to optical pulses
- Is frequency specific
- Uses a narrowband laser to generate the optical pulse

3.13.2 MULTIPLEXER/ DEMULTIPLEXER:

- Combines/separates discrete wavelengths

3.13.3 AMPLIFIER:

- Pre-amplifier boosts signal pulses at the receive side
- Post-amplifier boosts signal pulses at the transmit side (post amplifier) and on the receive side (preamplifier)
- In line amplifiers (ILA) are placed at different distances from the source to provide recovery of the signal before it is degraded by loss.
- EDFA (Eribium Doped Fiber Amplifier) is the most popular amplifier.

3.13.4 OPTICAL FIBER (MEDIA):

- Transmission media to carry optical pulses
- Many different kinds of fiber are used
- Often deployed in sheaths of 144–256 fibers

3.13.5 RECEIVER (RECEIVE TRANSPONDER)

- Changes optical pulses back to electrical bits
- Uses wideband laser to provide the optical pulse

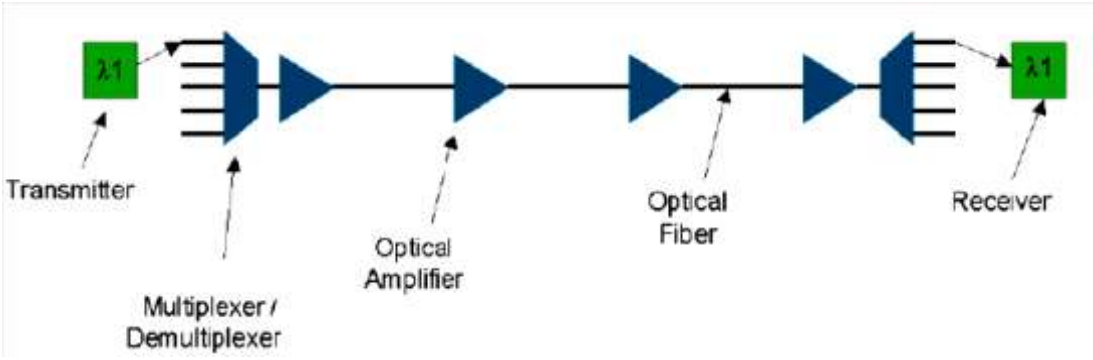


Figure 3: DWDM System Components

3.14 BENEFITS OF DWDM

- Increases bandwidth (speed and distance)
- Does not require replacement or upgrade their existing legacy systems
- Provides "next generation" technologies to meet growing data needs
- Less costly in the long run because increased fiber capacity is automatically available; don't have to upgrade all the time

3.15 CONCLUSION

DWDM promises to solve the "fiber exhaust" problem and is expected to be the central technology in the all-optical networks of the future. This increase means that the incoming optical signals are assigned to specific wavelengths within a designated frequency band, then multiplexed onto one fiber. This process allows for multiple video, audio, and data channels to be transmitted over one fiber while maintaining system performance and enhancing transport systems. This technology responds to the growing need for efficient and capable data transmission by working with different formats, such as SONET/SDH, while increasing bandwidth.

4 MLLN

4.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Role of Leased Line in Telecom
- Types of leased lines
- Managed Leased Line network (MLLN) and its Network Elements
- MLLN Network Architecture

4.2 INTRODUCTION

Leased lines are dedicated circuits provided by Basic Service Providers (BSPs), which provide permanent connectivity to the Internet. Leased lines provide the last mile access from the user premises to the ISP. They provide permanent connection as compared to the temporary connectivity through dialup access. The quality of the connection is far superior to what is normally available through dialup, thanks to digital signaling, less noise, fewer exchanges etc.

4.3 ROLE OF LEASED LINE IN TELECOM

When you conduct business on the Internet, your company needs access that is dependable and fast. Time is money, and downtime or slow transfers can cost many times more than what you actually pay for your connections. A leased line is a permanent fiber optic or telephone connection between two points set up by a telecommunications carrier. A leased line is also sometimes referred to as a dedicated line. It is a non switched line, i.e., it is a non-exchange line. They can be used for telephone, data, or Internet services. Oftentimes businesses will use a leased line to connect to geographically distant offices because it guarantees bandwidth for network traffic. For example, a bank may use a leased line in order to easily transfer financial information from one office to another. A leased line can span long or short distances and customers generally pay a flat monthly rate for the service depending on the distance between the two points. Leased lines do not have telephone numbers because each side of the line is always connected to one another, as opposed to telephone lines which reuse the same lines for numerous conversations through a process called "switching." The information sent through the leased line travels along dedicated secure channels, eliminating the congestion that occurs in shared networks.

4.4 SERVICES OFFERED THROUGH LEASED LINE

- **Speech Circuits:** (Hot lines or Private Wire): Between two locations in one city/ different cities for the same applicant. The terminating equipment at both ends is telephone without dialing facility.
- **Data Circuits:** To transmit data between computers or any other type of electronic information devices.

- Local (within city) and long distance (intercity) data circuits at low, medium and high speeds, i.e., from 64 Kbps to nx64 Kbps to 2 Mbps to STM-1 (155 Mbps) and beyond.
- Dedicated path between two points
- Private Data Network – More than one local or long distance leased circuits converging on a location such that data from one leased circuit can be transferred automatically to another leased circuit for the same subscriber.
- Mainly used by banks, other financial institutions, corporate, government, etc to build their own private data network interconnection various offices and their computer systems.

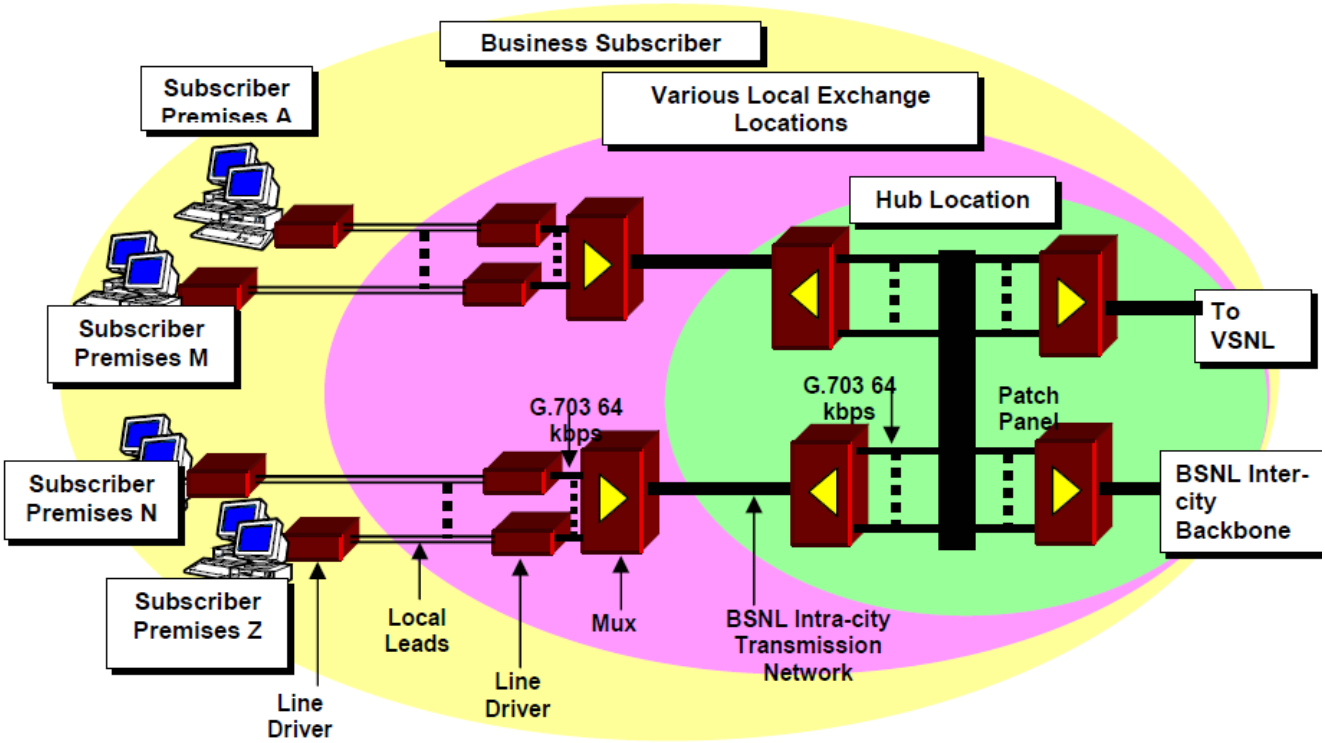


Fig.1 Typical Leased Line Network Set-up

Advantages

It provides permanent, reliable, high-speed connectivity as compared to the temporary connectivity of dial up access. The quality of the connection is far superior to what is normally available through dialup, because of the digital signaling, less noise, fewer exchanges etc.

Disadvantages

Leased bandwidth prices are quite high, compared to dialup bandwidth of comparable size. Entry level annual port prices are also high at present, so that this access method is only feasible beyond a fairly high threshold level. Permanent connectivity to the Net exposes the organization to a variety of threats including hacking, malicious code including active vandals, viruses, Trojan Horses, macros, denial of service attacks etc.

4.5 TYPES OF LEASED LINE

4.5.1 WIRE-LINE LEASE LINE SERVICES

Before year 2000, limited development in computing technology, limited options available with the operators were being offered to customers. Leased line of discreet capacity of 64Kbps, 2Mbps etc. were only made available to the customers due to non-availability of options for providing leased line of intermediate capacity. The subscriber therefore always suffer either by subscribing option with less than the capacity of their requirement or by paying more for subscribing lease line capacity more than their requirement. However, as more and more business introduces computer and its networking foe increasing efficiency and ease of operations, demand for such networks increases. This increasing demand of lease line networks in conjunction with the development in computing technology forced the operators to set up a service platform which can provide a reliable, flexible, transparent and secure solution. BSNL launched following solution to meet the requirement of its customers.

4.5.2 MANAGED LEASED LINE NETWORK (MLLN)

MLLN solution uses existing copper access network. It provides subscriber flexible option of choosing lease line capacity in multiple of 64Kbps from 64Kbps to 2Mbps unlike earlier solution. Customer can build a highly secured and reliable network for sharing information between various entities connected through this networking solution.

The network is built up with three elements viz, Digital Cross Connect (DXC), Virtual Multiplexer (VMUX) and Network Terminating Unit (NTU). DXC is at highest level in network element hierarchy and can modularly expanded with the customer demand from 64P to 960P capacity. VMUX provide network connectivity to the customer with NTU at the subscriber premises. The versatile NTU is configurable through software for increasing or decreasing lease line capacity in multiple of 64Kbps and having various interface options for connectivity with subscriber networking equipment. The NTU accepts G703, V.35 and Ethernet inputs. It relives customers of expenditure required to be incurred for purchase of equipment required of interface conversion. The physical leased lines and all these elements can be provisioned and monitored through a elaborated, highly secured disaster resistance monitoring, provisioning and fault control system at Bangalore with hot standby at Pune. Hot standby system ensures up and running services to the customer in the extreme disaster conditions. It has elaborated performance monitoring and fault identification system. This system also provides easy and flexible service provisioning. Controlled access to this system can be made available to the customer for on line monitoring of networking services provided. Customers can also allow to flexibly change lease line capacity in time domain as per his requirement. The system has rich report generation option by keeping continuous log of network and connected equipments. The system thus enables transparent execution of Service Level Agreement (SLA) of the order 99.999 (five nine).

4.5.3 MULTI PROTOCOL LABEL SWITCHING– VIRTUAL PRIVATE NETWORK (MPLS – VPN)

Application in convergence scenario generating IP based packet traffic from Voice, Data and Video applications. Efficient and secured IP based packet network therefore required to carry such traffic to the different entities in a business spread across wide geographical area. Sales related services demands access to information required by moving

sales representatives too any where and at any time. BSNL to cater such demand in secure but flexible environment created nation wide highly efficient traffic and quality sensitive network based on MPLS technology. A core network of highly efficient, high speed MPLS 110 routers is established with large no edge routers capable of accepting packetized data from almost all type of standard interfaces.

MPLS based VPN can be built up by the customer with different interface equipment at customer premises. This network can carry customer's traffic in highly secured mode with different QoS option. The lease line network is capable of providing lease line of virtually of any capacity which an application demands in present scenario. Point to multipoint connectivity can be provided to the customers to reduce number of physical lease line required in conventional lease line network solution. Connectivity while on move, particularly to sales representatives and customers can also be provided through secure mode.

4.5.4 WIRE-LESS LEASE LINE SERVICES

Offices and entities in far flung, difficult and isolated areas are also required to be connected in a business. Quick connectivity in congested city needs a system very different from present conventional wire-line based lease line solution. Further, new business models are also being evolved which demands connectivity, transfer of information for business strategies and decisions. Wireless networking solution is the only possible option to cater such demands.

4.5.5 SATELLITE BASED LEASE LINE (KU BAND) NETWORK

BSNL has established a wireless Ku-Band VSAT network with Hub earth station at Bangalore. Lease line of different bandwidth capacity from 64 Kbps to 2 Mbps can be provided to the customers. It needs installation of small terminal with out door unit having dish antenna of 0.75 M to 1.8M size and modem like Indoor unit. The subscriber unit can be installed at any far flung, difficult or isolated place. Highly congested areas where wire-line solution is not possible can also be provided connectivity with this option.

4.5.6 CDMA WIRE-LESS BASED LINE NETWORK

CDMA based wire-less data and voice services network has been developed by BSNL. This network is primarily used to provide wireless voice and internet based data services. However, the CDMA wireless network is also being used to build up lease line network in areas to the advantage of customers.

4.6 DRAWBACK OF TRADITIONAL LEASED LINE CIRCUITS

1. Limited range of services - Only Plain Leased Line Service, Data cards support only up to 64 kbps, no support for N x 64 Kbps.
2. From Operator point of view in case of Leased Line Circuit different boxes from different vendors so difficult to manage & control.
3. No Centralized Monitoring or alarm or performance monitoring.

Therefore we should have a control to all this, we are able to identify before the customer know which circuit has gone faulty. The solution to this is **MLLN**

4.7 MLLN – MANAGED LEASED LINE NETWORK

The MLLN service is specially designed mainly for having effective control and monitoring on the leased line so that the down time is minimized and the circuit efficiency is increased. This mainly deals with data circuits ranging from 64 Kbps to 2048 Kbps.

4.7.1 MLLN FEATURES:

1. MLLN is an integrated, fully managed , multi service digital network platform through which service provider can offer a wide range of service at an optimal cost to business subscriber.
2. Using NMS, MLLN can provide high speed Leased Line with improved QoS, high availability & reliability.
3. NMS supports service provisioning, Network optimization, planning & service monitoring.
4. System offers end to end circuit creation and modification, circuit loop testing & fault isolation, automatic rerouting of traffic in case of trunk failure, software programmability of NTU etc.
5. Banking, Financial institution, Stock market, paper industry, broadcasting & Internet service Provider main customers for MLLN.

4.7.2 MLLN ADVANTAGES:

1. 24 hrs Performance Monitoring of the circuit. (how much time circuit time up & down and the reason for down time e.g MODEM switch off or other reason)
2. Circuit fault reports generated proactively.(Before customer know we should detect the fault & rectify it)
3. On Demand the Bandwidth can be increased. (without changing the MODEM recreate the circuit with the same MODEM)
4. Protection against the failure of the circuit (through recovery Management process either automatic or manually)
5. Long drive on single copper pair.(for 64 kbps – 7 kms & for 2mbps – 3.5 kms)
6. Centrally managed from ROT connected to the NMS

4.7.3 APPLICATION OF MLLN:

1. Corporate high speed internet access through Broadband.
2. LAN interconnection.
3. Hotline connectivity for voice.
4. Point to point connection for data circuit.
5. Point to multipoint connection.
6. EPABX Interconnection.
7. VPN on MLLN Network.
8. Extension of VPN (MPLS) to Customer.

4.8 KEY ELEMENTS OF MLLN:

1. MLLN Nodes
2. Servers
3. Workstations
4. Networking Equipment
5. Others (Printers, UPS etc)

4.8.1 MLLN NODES

- DXC (Digital Cross-Connect)
- VMUX (Versatile Multiplexer)
- NTU (Network Terminating Unit)
- NMS (Network Management System)

4.8.2 SERVERS

- Database Server
- NMS Application Servers
- Billing and Accounting Servers
- Web Self Care Servers
- Proxy Servers

4.8.3 WORKSTATIONS

- Local Operator Terminals
- Remote Operator Terminals

4.8.4 NETWORKING EQUIPMENT

- Router
- LAN Switch
- RAS
- Firewall
- Remote Operator Terminal Connectivity Equipment
- Grooming Mux at Main and DR Sites
- Connectivity equipments at Remote Sites
-

4.8.5 OTHERS

- Un-interrupted power supply
- Printers
- Messaging System

4.9 MLLN NETWORK ARCHITECTURE:

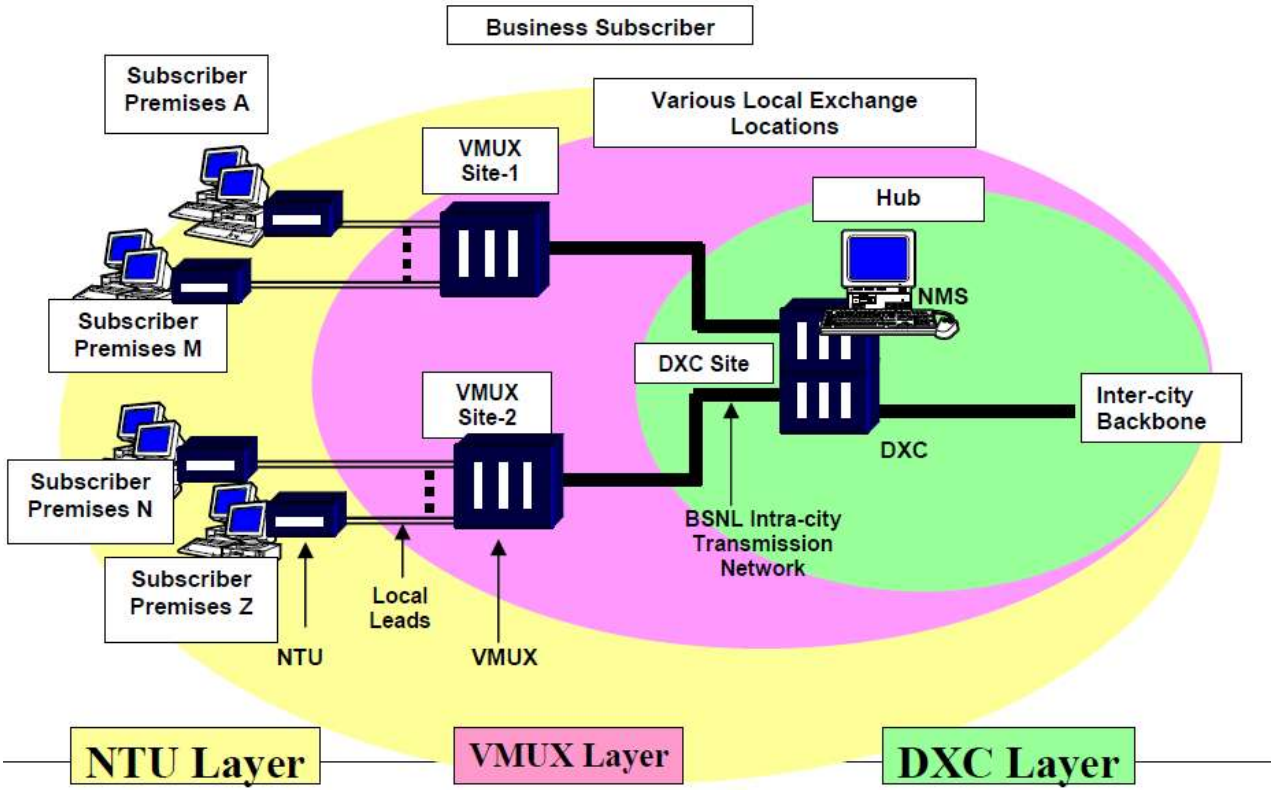


Fig. 2 Functional Block of MLLN

4.9.1 DXC

Capacity

- DXC (64 ports upgradeable to 128 ports)
- DXC (96 ports upgradeable to 128 ports)
- DXC (128 ports upgradeable to 256 ports)
- DXC (256 ports)

1/0 cross-connect capability

Non-Blocking Architecture

Redundancy

- Power Supply
- Switching Matrix
- Cross-connect Memory

Expansion to be made possible by addition of cards only.

Fully Managed from Centralized NMS

4.9.2 VMUX

Type - I, Type - II, Type - III with the configurations given below

	64 kbps	**N*64 kbps**	**E1 Links**
VMUX Type I	32	8	12
VMUX Type II	16	4	4
VMUX Type III	8	4	4

Expansion to be made possible on the same chassis by addition of cards

Type III VMUX

- 230V AC Powered
- -48V DC Powered

VMUX to be able to extend hotline circuits

- Point to point and Point to Multi-point circuit routing should be possible

HDSL Driving Distance:

- 3.5km at 2Mbps
- 5 km at 1Mbps
- 7km for 64/128kbps (at 0.5mm dia copper cable

4.9.3 NTU (NETWORK TERMINATING UNIT)

Capacity

- 64/128kbps NTU with V.35
- 64/128kbps NTU with G.703
- N x 64kbps NTU with V.35
- N x 64kbps NTU with G.703
- N x 64kbps NTU with Ethernet Interface

Line Loop Testing as per ITU-T Rec V.54

64kbps NTU to work up to 128kbps

N x 64kbps NTU to work up to 2Mbps

NTU to send power off signal to the NMS at the time of NTU getting switched off.

STU-160 works up to 128kbps

CTU-S and CTU-R works up to 2Mbps on a single pair of copper

All NTU's support V.54 line loop testing and support dying gasp to send power off signal at time of power off condition.

4.9.4 NMS (NETWORK MANAGEMENT SYSTEM)

- MLLN NMS

- Billing and Accounting System
- Web Self-care system
- We have offered Tellabs Network Manager Release 13 to meet the requirements
- MLLN NMS performs all the management functions on the network
- Supports regional partitioning and VPN capabilities
- Offered Performance Monitoring, Recovery, Reporting Packages
- Offered HP Open view and Cisco works which would reside on SNMP server for managing the servers and IT elements

4.10 CONCLUSION

Leased lines provides a scalable access method, important particularly for organizations with large user groups, including corporate, banks and financial institutions, educational and R&D organizations, government, military etc. Starting typically with 64 Kbps, it is possible to deploy a scalable architecture, with multiples of E1 (2 MBPS) pipes, providing the necessary bandwidth. In fact, leased access becomes a must for large organizations in most situations. The lease line networks in BSNL has been developed and groomed over a period of time catering demand of all type of customers. These networks has been integrated together to leverage the advantage of making available both wire-line and wire-less solution to the customers as per their needs and benefit.

5 MPLS VPN

5.1 LEARNING OBJECTIVE

This chapter covers the concept of MPLS. MPLS (Multi Protocol Label Switching) is a mechanism that switches traffic based on labels instead of routing traffic. MPLS VPN is a popular technique to build VPNs for customers over the MPLS provider network.
After reading the chapter the participants will be able to understand the concept of LSP, traffic engineering, and loop detection.

5.2 INTRODUCTION

Multi Protocol Label Switching (MPLS) is an efficient encapsulation mechanism that uses "Labels" appended to packets (IP packets, AAL5 frames) for transport of data. MPLS packets can run on other layer 2 technologies such as ATM, FR, PPP, POS, Ethernet. Other layer 2 technologies can be run over an MPLS network. Labels can be used as designators. For example—IP prefixes, ATM VC, or a bandwidth guaranteed path.

It operates at a layer that is generally considered to lie between traditional definitions of Layer 2 (data link layer) and Layer 3 (network layer or IP Layer), and thus MPLS is often referred to as a "Layer 2.5" protocol. It was designed to provide a unified data-carrying service for both circuit-based clients and packet-switching clients, which provide a data-gram service model. It can be used to carry many different kinds of traffic, including IP packets, as well as native ATM, SONET, Frame relay and Ethernet frames. The IP network has emerged as the network for providing converged, differentiated classed of services to user with optimal use of resources and also to address the issues related to Class of service (CoS) and Quality of Service (QoS). MPLS is the technology that addresses all the issues in the most efficient manner. MPLS is a packet-forwarding technology that uses labels to make data forwarding decisions.

5.3 DRAWBACKS OF TRADITIONAL IP FORWARDING

- Routing protocols are used to distribute Layer 3 routing information and therefore every router may need full Internet routing information (more than100,000 routes).
- Forwarding is based on the destination address only.
- Routing lookups are performed on every hop that slows down the forwarding operation.
- Packets can't be given priority. Though TOS field is there in IP packets through which priority can be given to packets but routers are designed to bypass the TOS field.
- Layer 2 devices have no knowledge of Layer 3 routing information —virtual circuits must be manually established.

5.4 MPLS ADVANTAGES

1. Specifies mechanisms to manage traffic flow of various granularities, such as flows between different hardware, machines, or even flows between different applications.

2. Create new services via flexible classification
3. Provides the ability to setup bandwidth guaranteed paths
4. Enable ATM switches to act as routers
5. MPLS remains independent of the Layer-2 & layer-3 protocols. Meaning thereby that label encapsulating the data packet does not depend upon layer 3 /layer 2 protocol of data. This justifies the name as multi protocol label switching.
6. Provides a means to map IP addresses to simple, fixed-length labels used by different packet-forwarding and packet-switching technologies
7. Interfaces to existing routing protocols such as resource reservation protocol (RSVP) and open shortest path first (OSPF).
8. Supports the IP, ATM, and frame- relay Layer-2 protocols.
9. MPLS gives network operators a great deal of flexibility to divert and route traffic around link failures, congestion, and bottlenecks.
10. From a Quality of Service (QoS) standpoint, ISPs will better be able to manage different kinds of data streams based on priority and service plan. For instance, those who subscribe to a premium service plan, or those who receive a lot of streaming media or high-bandwidth contentcan see minimal latency and packet loss.
11. Enable ATM switches to act as routers

5.5 MPLS HEADER

5.5.1 What is a MPLS header?

MPLS works by prefixing packets with an MPLS header containing one or more 'labels'.

This is called a label stack. Each label stack entry contains four fields: -

- 20-bit label value (This is MPLS Label)
- 3-bit Experimental field used normally for providing for QoS (Quality of Service)
- 1-bit bottom of stack flag. If this is 1, signifies that the current label is the last in the stack.
- 8-bit TTL (time to live) field.

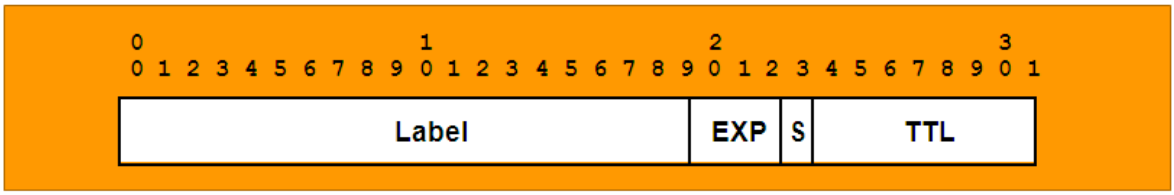


Fig:1 MPLS Header format

5.5.2 MPLS Label Stack

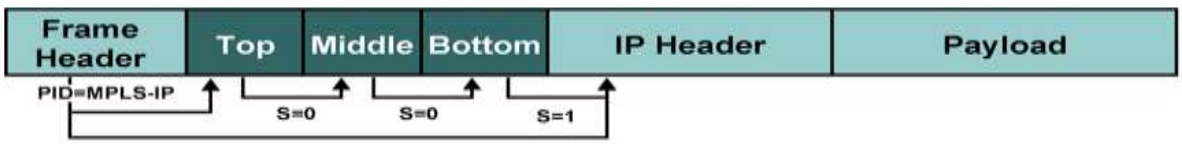


Fig:2 MPLS Label Stack

- Protocol identifier in a Layer 2 header specifies that the payload starts with a label (labels) and is followedby an IP header.
- Bottom-of-stack bit indicates whether the next headeris another label or a Layer 3 header.
- Receiving router uses the top label only.
- Usually only one label is assigned to a packet.
- The following scenarios may produce more thanone label:
  - MPLS VPNs (two labels: The top label points to the egressrouter and the second label identifies the VPN.)
  - MPLS TE (two or more labels: The top label points to the endpoint of the traffic engineering tunnel and the secondlabel points to the destination.)
  - MPLS VPNs combined with MPLS TE (three or more labels.)

5.6 VARIOUS ROUTING FUNCTION UNITS & ROUTERS IN MPLS

Routing function in MPLS can be described on the basis of some units, which are defined as follows:

Label: A label is an identifier, which indicates the path a packet, should traverse. Label is carried along with the packet. The receiving router examines the packet for its label content to determine the next hop. Once a packet has been labeled, the rest of the journey of the packet through the backbone is based on label switching. Since every intermediate router has to look in to the label for routing the decision making at the level of router becomes fast.

Label Creation: Every entry in routing table (build by using any IGP protocol) is assigned a unique 20-bit label.

SWAP: Every incoming label is replaced by a new outgoing label (As per the path to be followed) and the packet is forwarded along the path associated with the new label.

PUSH: A new label is pushed on top of the packet, effectively "encapsulating" the original IP packet in a layer of MPLS.

POP: The label is removed from the packet effectively "de-encapsulating". If the popped label was the last on the label stack, the packet "leaves" the MPLS tunnel.

LER: A router that operates at the edge of the access network and MPLS network LER performs the PUSH and POP functions and is also the interface between access and MPLS network, commonly known as Edge router.

LSR: An LSR is a high-speed router device in the core of an MPLS network, normally called Core routers. These routers perform swapping functions and participate in the establishment of Label Switch Path (LSP)

Ingress / Egress Routers: The routers receiving the incoming traffic or performing the first PUSH function are ingress routers and routers receiving the terminating traffic or

performing the POP function are Egress routers. The same router performs both functionality i.e. Ingress and Egress. The routers performing these functions are LER.

FEC: The forward equivalence class (FEC) is a representation of a group of packets that share the same requirements for their transport. All packets in such a group are provided the same treatment en route to the destination. As opposed to conventional IP forwarding, in MPLS, the assignment of a particular packet to a particular FEC is done just once, as the packet enters the network at the edge router.

5.7. BASIC MPLS OPERATION

When packets enter a MPLS-based network, Label Edge Routers (LERs) give them one or more labels (identifiers). These labels not only contain information based on the routing table entry (i.e., destination, bandwidth, delay, and other metrics), but also refer to the IP header field (source IP address), Layer 4 socket number information, and differentiated service.

Once this classification is complete and mapped, different packets are assigned to corresponding Labeled Switch Paths (LSPs), where Label Switch Routers (LSRs) place outgoing labels on the packets. With these LSPs, network operators can divert and route traffic based on data-stream type and Internet-access customer

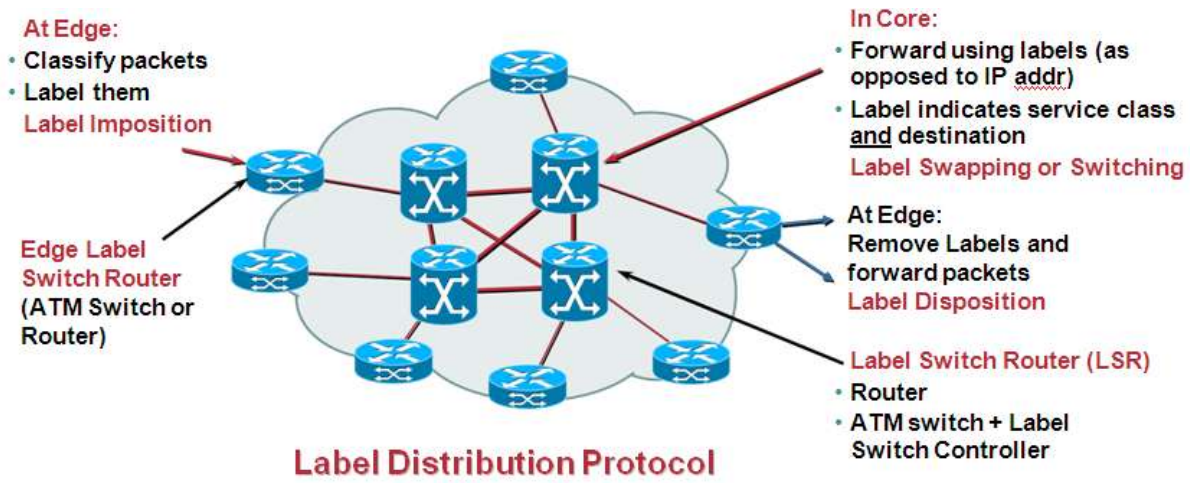


Fig. 3: LDP

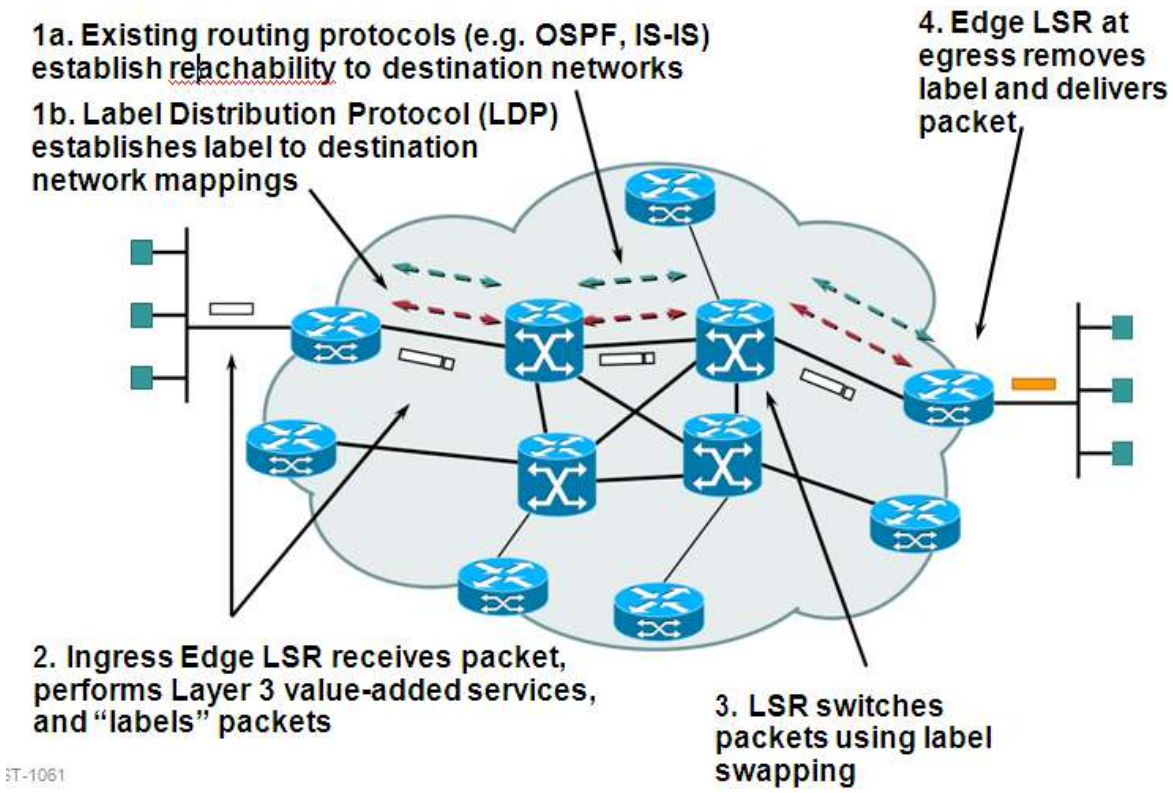


Fig: 4 Forwarding of Packets in MPLS network

The following steps must be taken for a data packet to travel through an MPLS domain:

- Label creation and distribution
- Label creation at each router
- Label-switched path creation
- Label insertion/table lookup
- Packet forwarding

5.8. MPLS ROUTER FUNCTIONALITY

MPLS Router functionality is divided into two major parts

5.8.1 Control plane: Exchanges Layer 3 routing information and labels. Control plane contains complex mechanisms to exchange routing information, such as OSPF, EIGRP, IS-IS, and BGP, and to exchange labels, such as TDP,LDP, BGP, and RSVP.

5.8.2 Data plane: Forwards packets based on labels. Data plane has a simple forwarding engine.

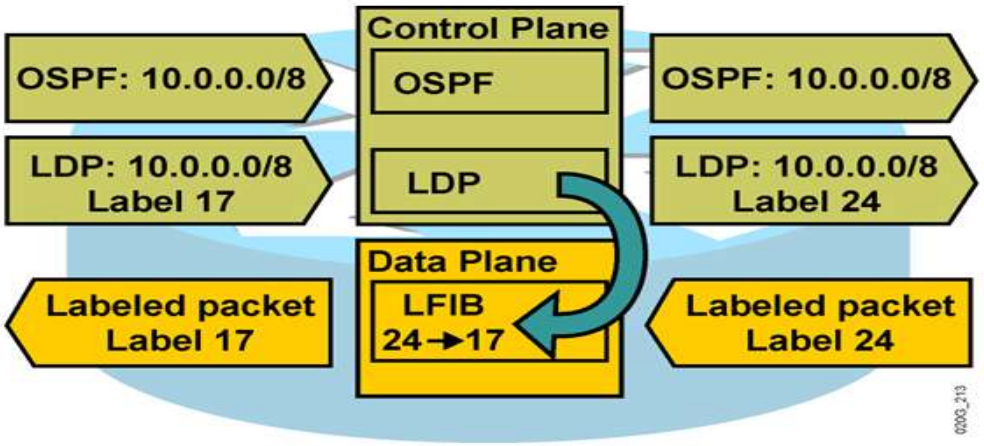


Fig:5 Control plane And Data plane

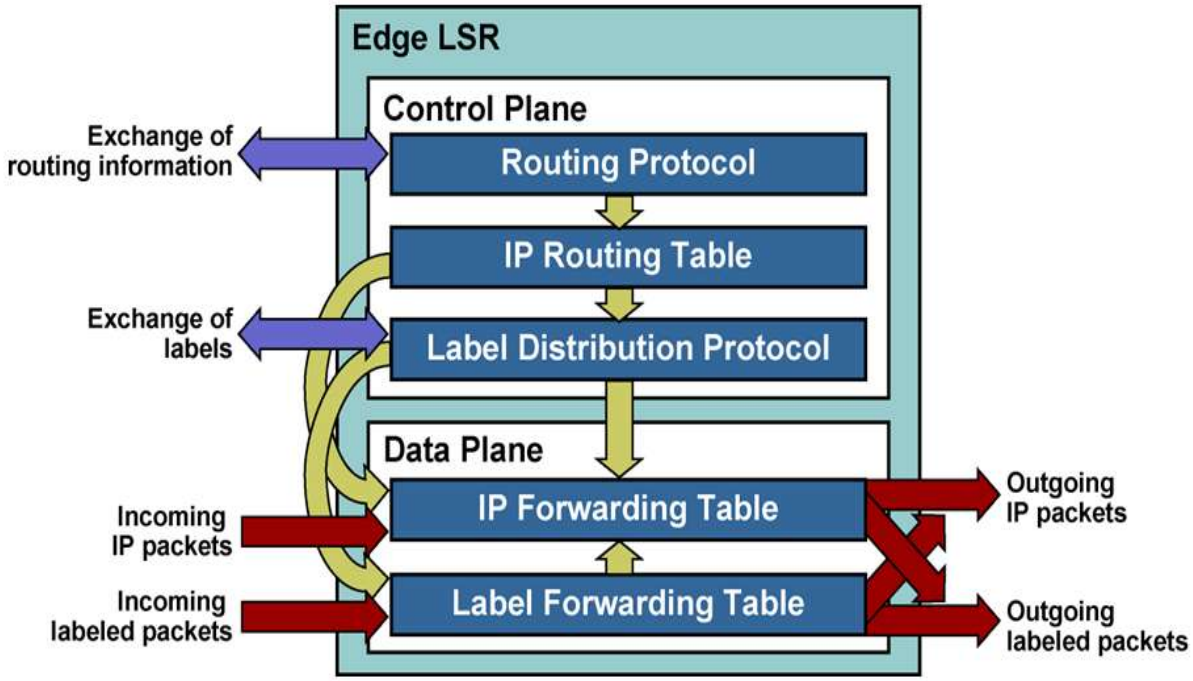


Fig:6 Architecture of LSR

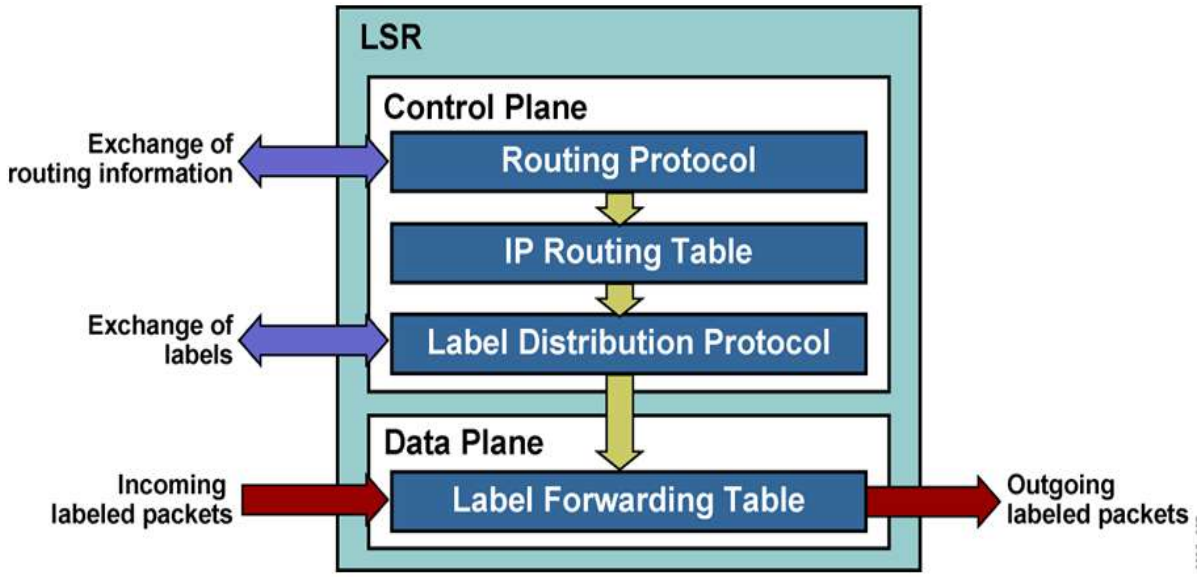


Fig:7 Lable Switch Router

5.9. LABEL DISTRIBUTION AND FORWARDING OF PACKETS IN MPLS NETWORKS

- OSPF, IS-IS, BGP are needed in the network
- They provide reachability
- Label distribution protocols distribute labels for - prefixes advertised by unicast routing protocols using Either a dedicated Label Distribution Protocol (LDP, Extending existing protocols like BGP to distribute Labels
- Defined in RFC 3035 and 3036.
- It Used to distribute Labels in a MPLS network, Forwarding Equivalence Class(How packets are mapped to LSPs (Label Switched Paths)), Advertise Labels per FEC, Reach destination a.b.c.d with label x and Discovery

5.9.1 Router Example: Forwarding Packets

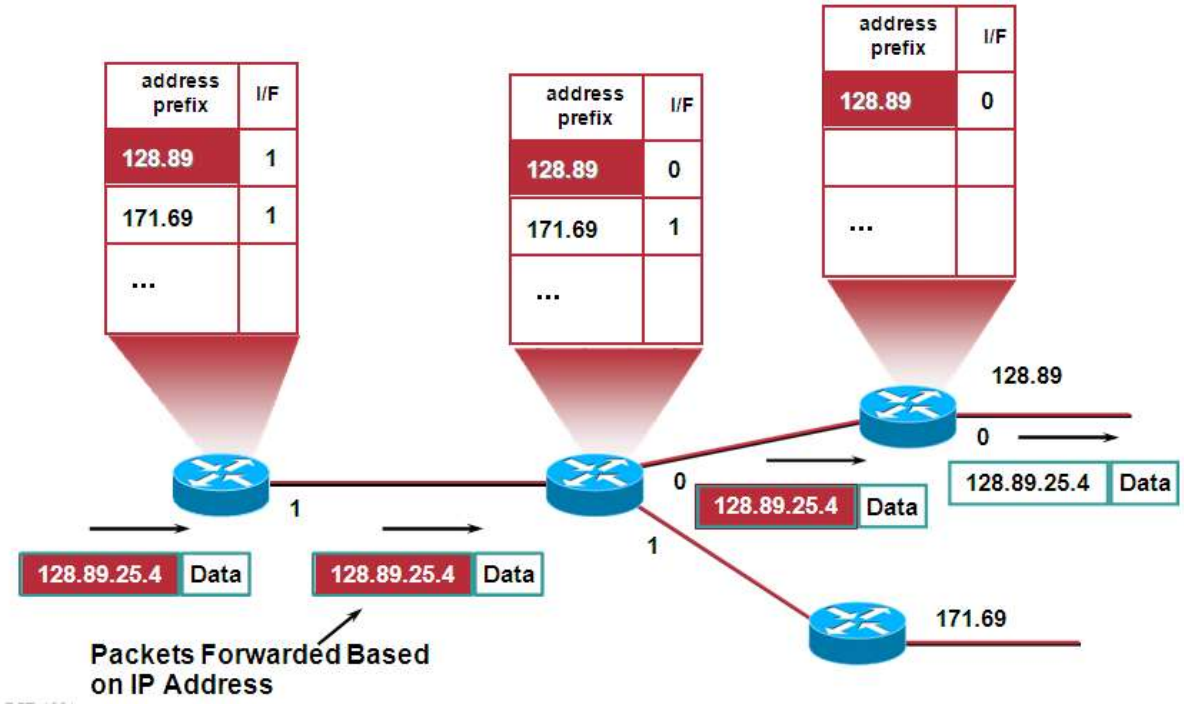


Fig:8 Packet Forwarding

5.9.2 MPLS Example: Routing Information

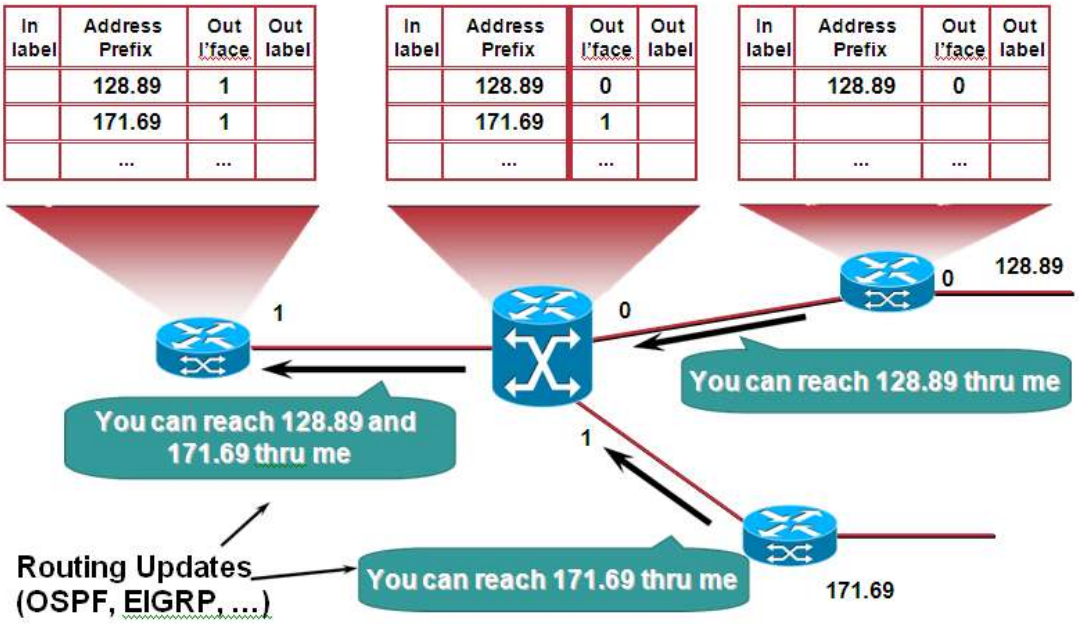


Fig:9 Routing Updates

5.9.3 MPLS Example: Assigning Labels

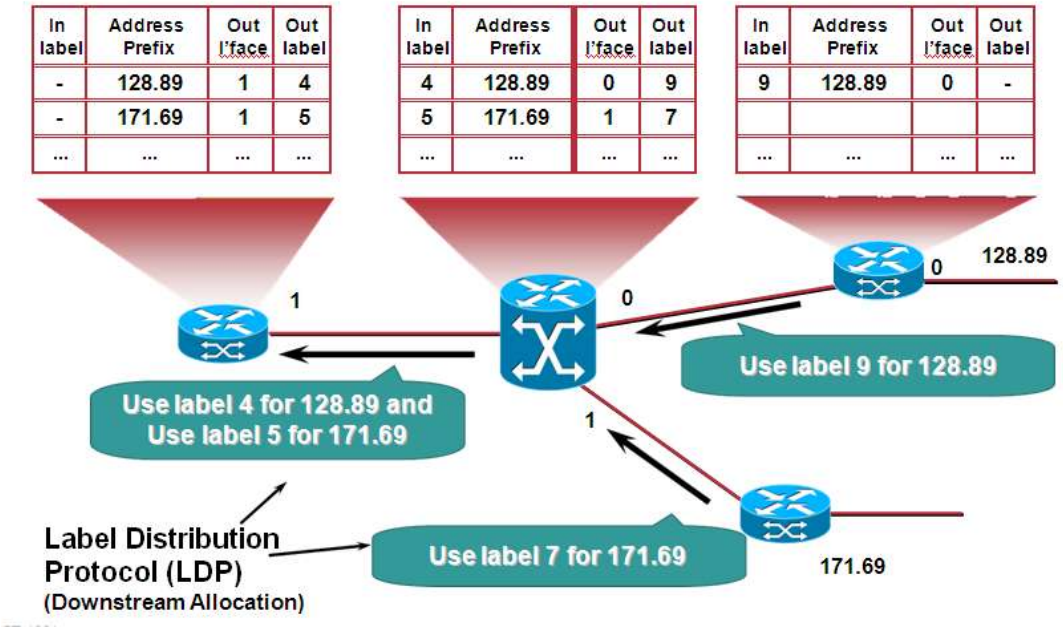


Fig:10 Lable Distribution

5.9.4 MPLS Example: Forwarding packets

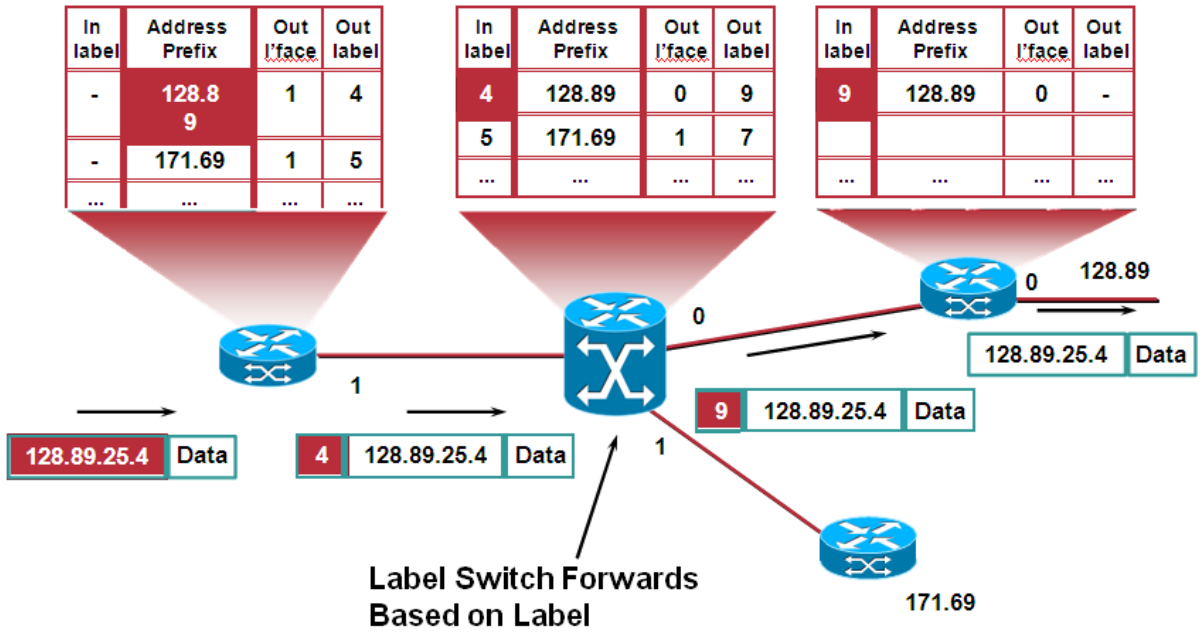


Fig:11 Labled Packet Forwarding

5.10. MPLS LABEL DISTRIBUTION PROTOCOLS

MPLS architecture does not mandate a single method of signaling for label distribution. Existing routing protocols, such as the border gateway protocol (BGP), have been enhanced to piggyback the label information within the contents of the protocol. The RSVP has also been extended to support piggybacked exchange of labels. A summary of the various schemes for label exchange is as follows:

- **LDP**—maps unicast IP destinations into labels
- **RSVP, CR–LDP**—used for traffic engineering and resource reservation
- **protocol-independent multicast (PIM)**—used for multicast states label mapping
- **BGP**—external labels (VPN)

The Internet Engineering Task Force (IETF) has also defined a new protocol known as the label distribution protocol (LDP) for explicit signaling and management of the label space. Extensions to the base LDP protocol have also been defined to support explicit routing based on QoS and CoS requirements. These extensions are captured in the constraint-based routing (CR)–LDP protocol definition. It is used to map FECs to labels, which, in turn, create LSPs. LDP sessions are established between LDP peers in the MPLS network (not necessarily adjacent)

5.10.1 LDP (Label Distribution Protocol)

LDP Protocol has the following functions:

- Neighbor discovery
  Discover directly attached Neighbors—pt-to-pt links (including Ethernet)
  Establish a session
  Exchange prefix/FEC and label information

- Extended Neighbor Discovery
  Establish peer relationship with another router that is not a neighbor
  Exchange FEC and label information
  May be needed to exchange service labels

5.10.2 TDP (Tag Distribution Protocol)

Tag Distribution Protocol—Cisco proprietary
Pre-cursor to LDP
Used for Cisco Tag Switching

- TDP and LDP supported on the same device
  Per neighbor/link basis
  Per target basis
  LDP is a superset of TDP
  Uses the same label/TAG
  Has different message formats

5.10.3 Other Label Distribution Protocol – BGP

- Used in the context of MPLS VPNs
- Need multiprotocol extensions to BGP
- Routers need to be BGP peers
-

The peersexchange the following types of LDP messages:

- **discovery messages**—announce and maintain the presence of an LSR in a network
- **session messages**—establish, maintain, and terminate sessions between LDP peers
- **advertisement messages**—create, change, and delete label mappings for FECs
- **notification messages**—provide advisory information and signal error information

5.11. SETTING UP LABEL-SWITCHED PATHS (LSPS)

MPLS provides the following two options to set up an LSP:

- **hop-by-hop routing**—Each LSR independently selects the next hop for a given FEC. This methodology is similar to that currently used in IP networks. The LSR uses any available routing protocols, such as OSPF, ATM private network-to-network interface(PNNI), etc.
- **explicit routing**—Explicit routing is similar to source routing. The ingress LSR (i.e., the LSR where the data flow to the network first starts) specifies the list of nodes through which the ER–LSP traverses. The path specified could be non-optimal, as well. Along the path, the resources may be reserved to ensure QoS to the data traffic. This eases traffic engineering throughout the network, and differentiated services can be provided using flows based on policies or network management methods.

The LSP setup for an FEC is unidirectional in nature. The return traffic must take another LSP.

MPLS VPNs

5.12. WHAT IS A VPN:

- VPN is a set of sites which are allowed tocommunicate with each other
- VPN is defined by a set of administrative policies
  Policies determine both connectivity and QoS among sites
  Policies established by VPN customers
  Policies could be implemented completely by VPNService Providers
  Using BGP/MPLS VPN mechanisms
- Flexible inter-site connectivity ranging from complete to partial mesh
- Sites may be either within the same or in different organizations (VPN can be either intranet or extranet)
- Site may be in more than one VPN (VPNs may overlap)

- Not all sites have to be connected to the sameservice provider (VPN can span multiple providers)

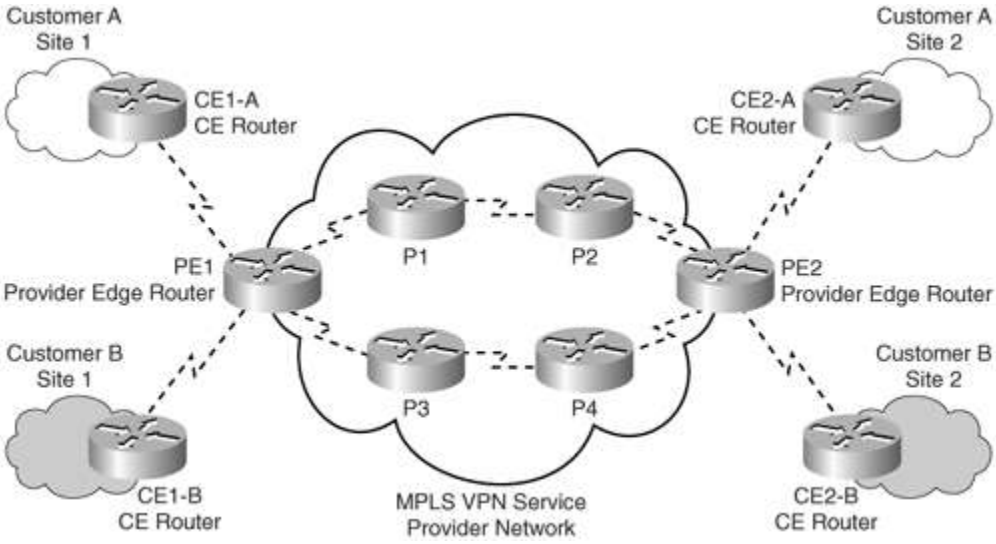


Fig: 12 MPLS VPN Architectures

Customer network— Consisted of the routers at the various customer sites. The routers connecting individual customers' sites to the service provider network were called customer edge (CE) routers.

Provider network— Used by the service provider to offer dedicated point-to-point links over infrastructure owned by the service provider. Service provider devices to which the CE routers were directly attached were called provider edge (PE) routers. In addition, the service provider network might consist of devices used for forwarding data in the backbone called provider (P) routers.

5.14. CLASSIFICATION OF VPN IMPLEMENTATION

Depending on the service provider's participation in customer routing, the VPN implementations can be classified broadly into one of the following:

- Overlay model
- Peer-to-peer model

5.14.1 OVERLAY MODEL

1. Service provider doesn't participate in customers routing, only provides transport to customer data using virtual point-to-point links. As a result, the service provider would only provide customers with virtual circuit connectivity at Layer 2.

2. If the virtual circuit was permanent or available for use by the customer at all times, it was called a permanent virtual circuit (PVC).

3. If the circuit was established by the provider on-demand, it was called a switched virtual circuit (SVC).

4. The primary drawback of an Overlay model was the full mesh of virtual circuits between all customer sites for optimal connectivity. It resembles the physical mesh

connectivity in case of leased lines. Overlay VPNs were initially implemented by the SP by providing either Layer 1 (physical layer) connectivity or a Layer 2 transport circuit between customer sites.

In the Layer 1 implementation, the SP would provide physical layer connectivity between customer sites, and the customer was responsible for all other layers. In the Layer 2 implementation, the SP was responsible for transportation of Layer 2 frames (or cells) between customer sites, which was traditionally implemented using either Frame Relay or ATM switches as PE devices. Therefore, the service provider was not aware of customer routing or routes.

Later, overlay VPNs were also implemented using VPN services over IP (Layer 3) with tunneling protocols like L2TP, GRE, and IPSec to interconnect customer sites. In all cases, the SP network was transparent to the customer, and the routing protocols were run directly between customer routers

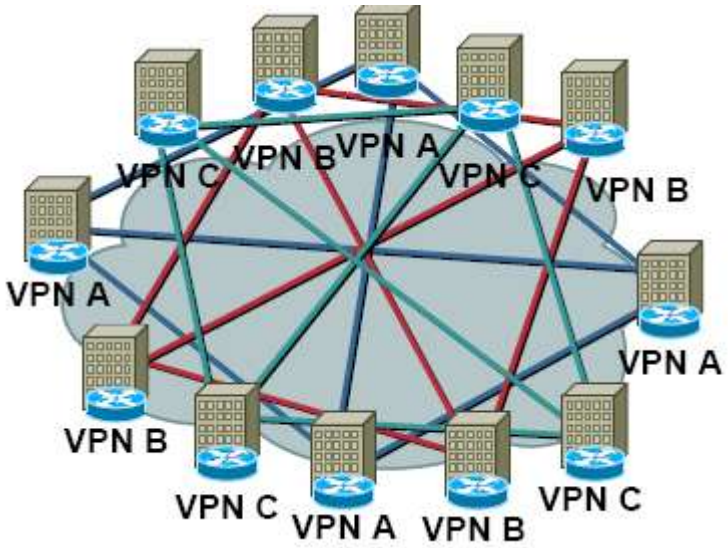


Fig:13

5.15 PEER-TO-PEER MODEL

The peer-to-peer model was developed to overcome the drawbacks of the Overlay model and provide customers with optimal data transport via the SP backbone. Hence, the service provider would actively participate in customer routing. In the peer-to-peer model, routing information is exchanged between the customer routers and the service provider routers, and customer data is transported across the service provider's core, optimally. Customer routing information is carried between routers in the provider network (P and PE routers) and customer network (CE routers). The peer-to-peer model, consequently, does not require the creation of virtual circuits. The CE routers exchange routes with the connected PE routers in the SP domain. Customer routing information is propagated across the SP backbone between PE and P routers and identifies the optimal path from one customer site to another.

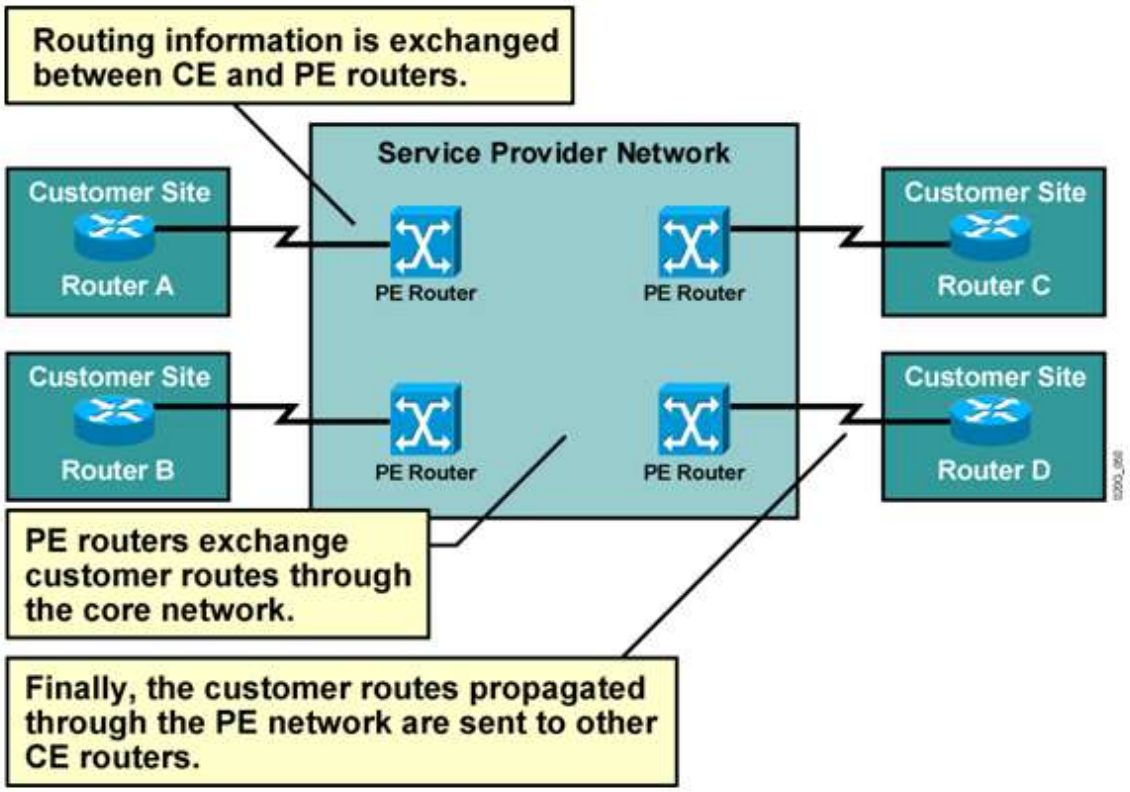


Fig:14 Peer – to – Peer VPN

5.15.1 DIAL VPN SERVICE

Mobile users of a corporate customer need to access their Corporate Network from remote sites. Dial VPN service enables to provide secure remote access to the mobile users of the Corporate. Dial VPN service, eliminates the burden of owning and maintaining remote access servers, modems, and phone lines at the Corporate Customer side. Currently accessible from PSTN (127233) & ISDN (27225) also from Broadband.

5.16. LAYER 2 AND LAYER 3 VPNS

- Layer 2 VPNs
  - Customer End points (CPE) connected via layer 2 such as Frame Relay DLCI, ATM VC or point to point connection
  - If it connects IP routers then peering or routing relationship is between the end points
  - Multiple logical connections (one with each end point)
- Layer 3 VPNs
  - Customer end points peer with provider routers Single peering relationship
  - No mesh of connections
  - -Provider network responsible for
  - Distributing routing information to VPN sites
  - Separation of routing tables from one VPN to another

5.17 MPLS VPN WORKING

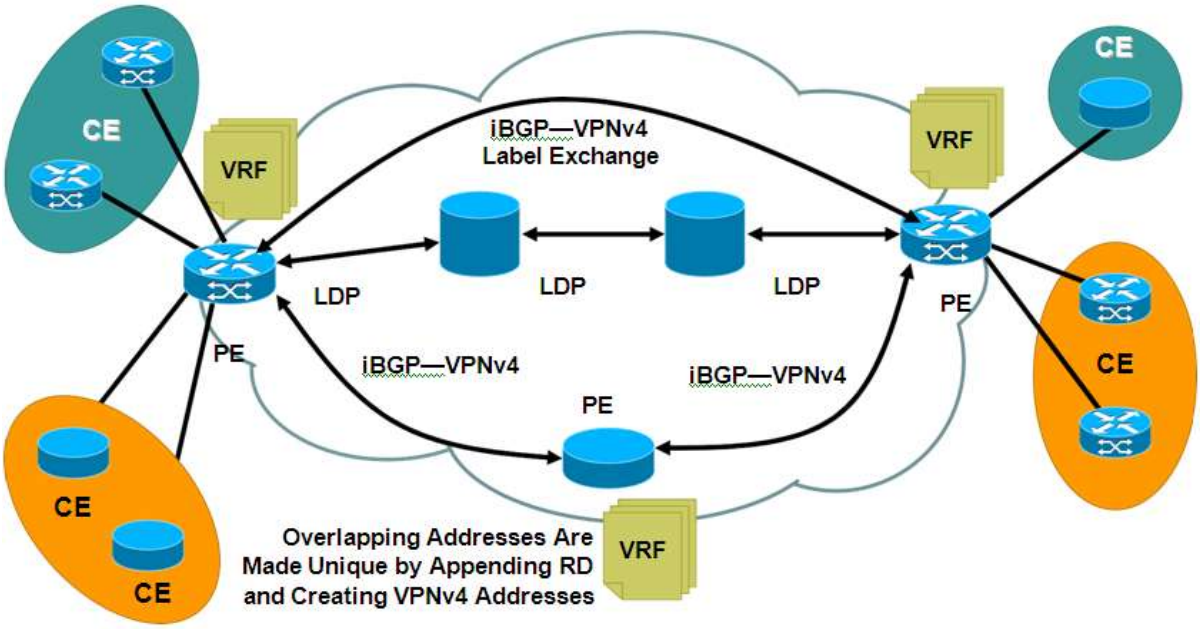


Fig: 15 MPLS VPN WORKING

5.17.1 MPLS LER ARCHITECTURE

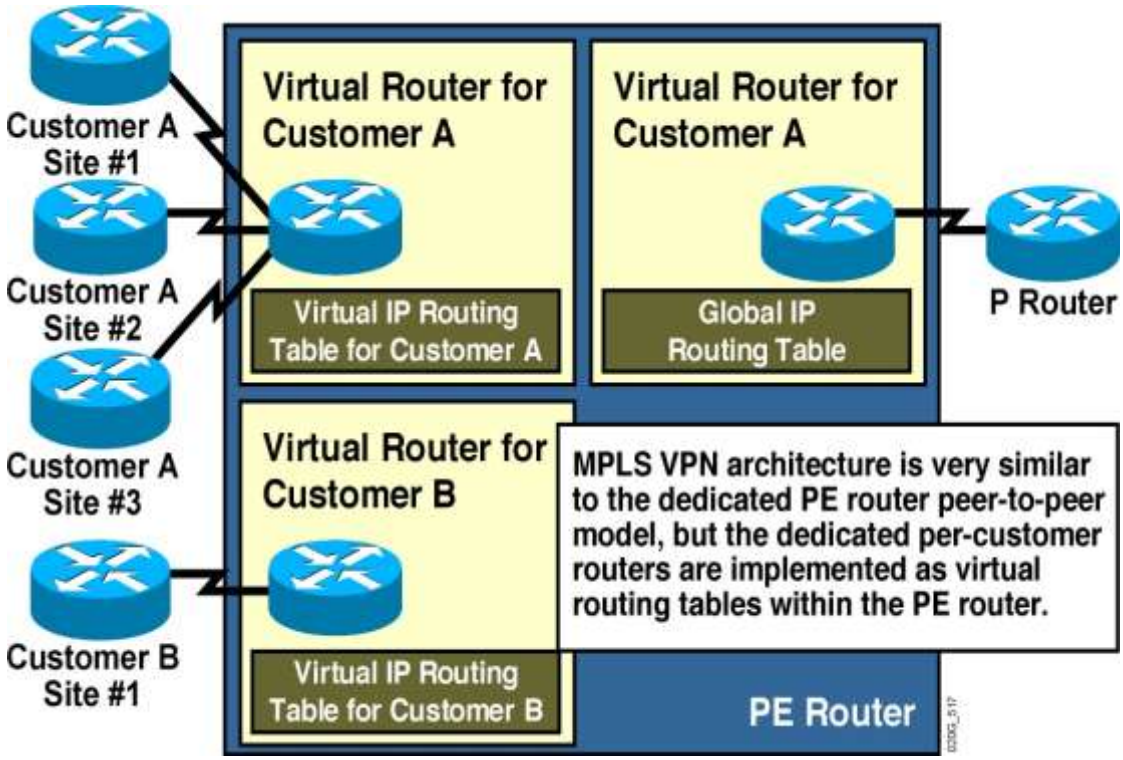
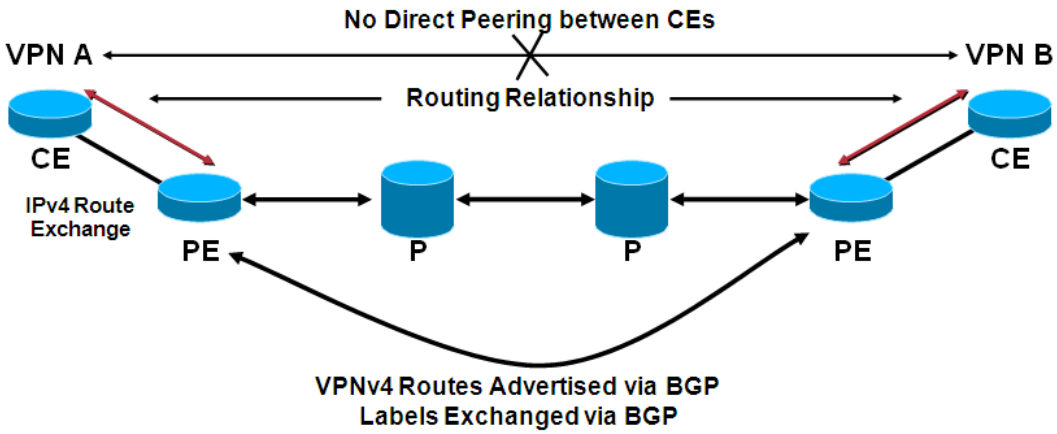


Fig:16 MPLS LER ARCHITECTURE

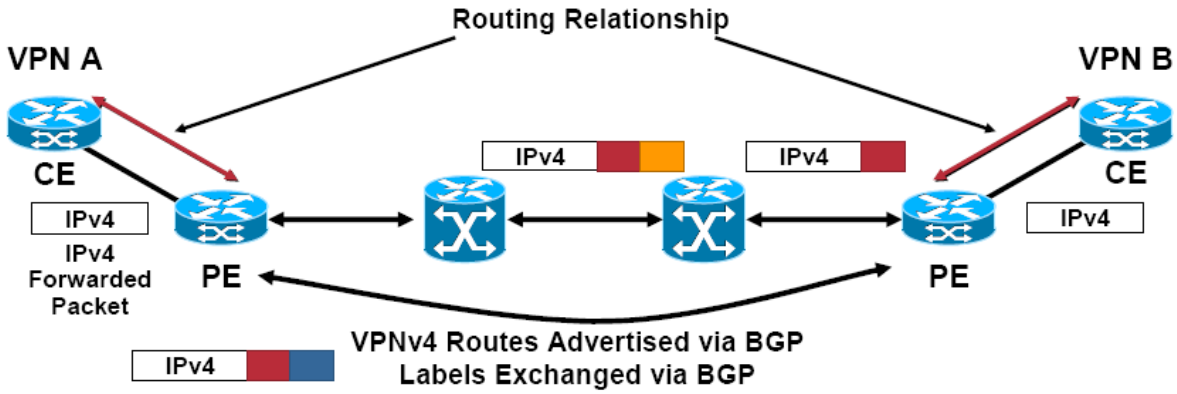
5.17.2 MPLS Control Plane Path:



- RD—8 Byte field—assigned by provider—significant to the provider network only
- VPNv4 Address: RD+VPN Prefix
- Unique RD per VPN makes the VPNv4 address unique

Fig:17 MPLS CONTOL PLANE PATH

5.17.3 MPLS DATA PLANE PATH:



- Ingress PE is imposing 2 labels

Fig:18 MPLS DATA PLANE PATH

5.18. ADVANTAGES OF MPLS VPNS OVER OTHER TECHNOLOGIES

BSNL's primary objectives in setting up the BGP/MPLS VPN network are:

1. Provide a diversified range of services (Layer 2, Layer 3 and Dial up VPNs) to meet the requirements of the entire spectrum of customers from Small and Medium to Large business enterprises and financial institutions.
2. Make the service very simple for customers to use even if they lack experience in IP routing.
3. Make the service very scalable and flexible to facilitate large-scale deployment.
4. Provide a reliable and amenable service.
5. Offering SLA to customers.
6. Capable of meeting a wide range of customer requirements, including security, quality of Service (QOS) and any-to-any connectivity.
7. Capable of offering fully managed services to customers.
8. Allow BSNL to introduce additional services such as bandwidth on demand etc over the same network.

5.19 CONCLUSION

MPLS VPN is a popular technique to build VPNs for customers over the MPLS provider network. The better understanding of MPLS – VPN facilitates the participants to better handle the O and M of MPLS network in real time scenario.

6 FTTH

6.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Concept of FTTH.
- Network Architecture of FTTH
- GPON and GEPON technology.

6.2 INTRODUCTION

Growing demand for high speed internet is the primary driver for the new access technologies which enable experiencing true broadband. Today's, there is an increasing demand for high bandwidth services in market around the world. However, traditional technologies, like Digital Subscriber Line (DSL) and cable modem technologies, commonly used for "broadband access," which have access speeds to the order of a megabit per second, with actual rates strongly dependent on distance from the exchange (central office) and quality of the copper infrastructure, can not fulfill today's customer demand for bandwidth hungry applications such as high-definition TV, high-speed Internet access, video on demand, IPTV, online gaming, distance learning etc. Amongst various technologies, the access methods based on the optical fiber has been given extra emphasis keeping into long term perspective of the country. It has many advantages over other competing access technologies of which 'Being Future Proof' and providing 'True Converged Network' for high quality multi-play are the salient ones. The stable and long term growth of Broadband is, therefore, going to be dependent on robust growth of fiber in the last mile.

However, for providing multi-play services (voice, video, data etc.) and other futuristic services fiber in the local loop is must. The subscriber market for multi-play is large and growing and includes both residences and businesses. Businesses need more bandwidth and many of the advanced services that only fiber can deliver. All view Multi- Play as a strong competitive service offering now and into the future and are looking at fiber as the way to deliver. Optical fiber cables have conventionally been used for long-distance communications. However, with the growing use of the Internet by businesses and general households in recent years, coupled with demands for increased capacity, the need for optical fiber cable for the last mile has increased. A primary consideration for providers is to decide whether to deploy an active (point-to-point) or passive (point-to-multipoint) fiber network.

6.3 FIBER TO THE X (FTTX)

Today, fiber networks come in many varieties, depending on the termination point: building (FTTB), home (FTTH), curb (FTTC) etc. For simplicity, most people have begun to refer to the fiber network as **FTTx,** in which x stands for the termination point. As telecommunications providers consider the best method for delivering fiber to their subscribers, they have a variety of FTTx architectures to consider. FTTH, FTTB, and FTTC each have different configurations and characteristics.

6.3.1 FTTH (FIBER TO THE HOME):

FTTH is now a cost-effective alternative to the traditional copper loop. "Fiber to the Home" is defined as a telecommunications architecture in which a communications path is provided over optical fiber cables extending from an Optical Line Terminal (OLT) unit located in central office (CO) connects to an Optical Network Terminal (ONT) at each premise. Both

OLTs and ONTs are active devices. This communications path is provided for the purpose of carrying telecommunications traffic to one or more subscribers and for one or more services (for example Internet Access, Telephony and/or Video-Television). FTTH consists of a single optical fiber cable from the base station to the home. The optical/electrical signals are converted and connection to the user's PC via an Ethernet card. FTTH is the final configuration of access networks using optical fiber cable.

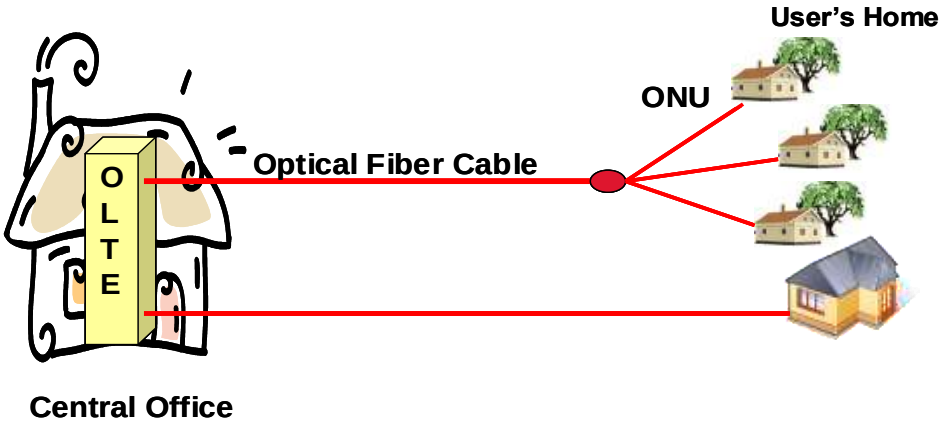


Fig. 1 FTTH Configuration

6.3.2 FTTB (FIBER TO THE BUILDING):

"Fiber to the Building" is defined as a telecommunications architecture in which a communications path is provided over optical fiber cables extending from an Optical Line Terminal (OLT) unit located in central office (CO) connects to an Optical Network Unit (ONU) at the boundary of the apartment or office or building enclosing the home or business of the subscriber or set of subscribers, but where the optical fiber terminates before reaching the home living space or business office space and where the access path continues to the subscriber over a physical medium other than optical fiber (for example copper loops).

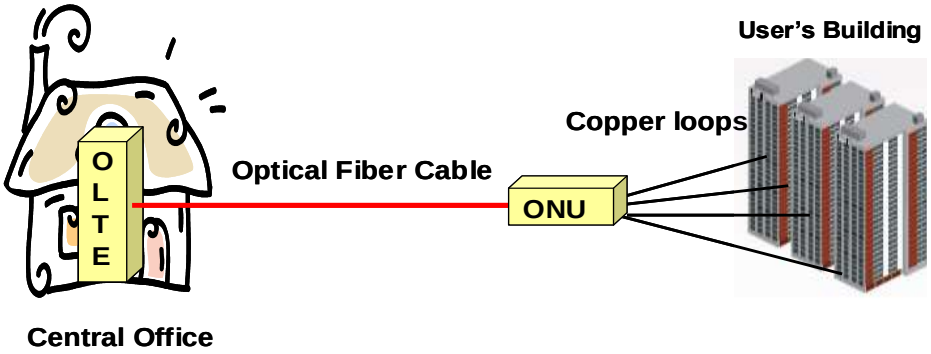


Fig. 2 FTTB Configuration

FTTB regarded as a transitional stage to FTTH. By introducing fiber cables from the fiber termination point to the home living space or business office space FTTB can be converted to full FTTH. Such a conversion is desirable as FTTH provides better capacity and longevity than FTTB. Optical fiber cable is installed up to the metallic cable installed within the building. A LAN or existing telephone metallic cable is then used to connect to the user.

6.3.3 FTTC (FIBER TO THE CURB):

A method of installing optical fiber cable by the curb near the user's home. An optical communications system is then used between the ONU installed outside (such as near the curb or on Street Cabinet) from the installation center. Finally, copper cable is used between the ONU and user.

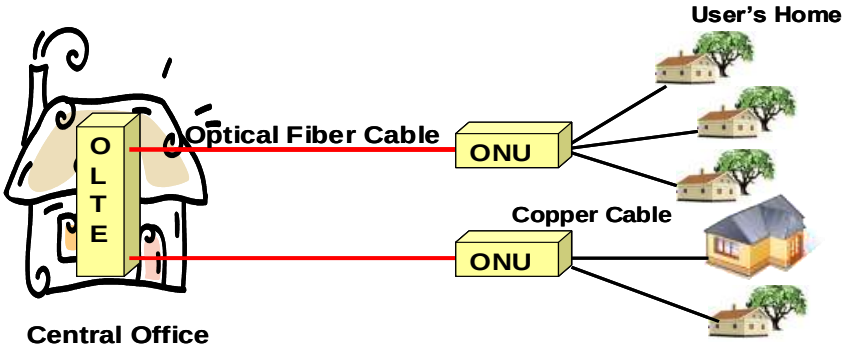


FIG.3 FTTC CONFIGURATION

6.4 WHY FTTH?

FTTH is a true multi-service communications access which simultaneously handles several phone calls, TV/video streams, and Internet users in the home/office. There are several advantages of deploying FTTH over other traditional access technologies as given below:

- FTTH provides end-users with a broad range of communications and entertainment services, and faster activation of new services.
- Competition is beginning to offer a "multi-play" (i.e., voice, video, data etc) bundle.
- FTTH provides Service Provider's with the ability to provide "cutting edge" technology and "best-in-class" services.
- Deploying a fiber optic cable to each premise will provide an extraordinary amount of bandwidth for future services.
- FTTH provides carriers with an opportunity to increase the average revenues per user (ARPU), to reduce the capital investment required to deliver multiple services, and to lower the costs of operating networks (fewer outdoor electronics, remote management, ..) will result in less operational expense.
- FTTH provides the community in which it's located with superior communications which enhance the efficiency of local business and thus deliver economic advantage for the community.
- Around the world FTTH is viewed as strategic national infrastructure similar to roads, railways, and telephone networks.

6.5 TECHNOLOGY OPTIONS FOR FTTH ARCHITECTURE:

When deciding which architecture to select a provider has many things to consider including the existing outside plant, network location, the cost of deploying the network,

subscriber density and the return on investment (ROI). At present different technology options are available for FTTH architecture .The network can be installed as an **active optical network**, or **a passive optical network (PON)**.

6.5.1 ACTIVE OPTICAL NETWORK

The active optical network implementation is known as the "Active Node" and is simply described as a "point-to-point" solution. Subscribers are provided a dedicated optical cable and the distribution points are handled by active optical equipment. These active architectures have been setup as either "**Home Run Fiber**" or "**Active Star Ethernet**".

6.5.1.1 Home Run Fiber (Point-to-Point) Architecture

A Home Run Fiber architecture is one in which a dedicated fiber line is connected at the central office (CO) to a piece of equipment called an Optical Line Terminator (OLT). At the end user location, the other side of the dedicated fiber connects to an Optical Network Terminal (ONT). Both OLTs and ONTs are active, or powered, devices, and each is equipped with an optical laser The Home Run fiber solution offers the most bandwidth for an end user and, therefore, also offers the greatest potential for growth. Over the long term Home Run Fiber is the most flexible architecture; however, it may be less attractive when the physical layer costs are considered. Because a dedicated fiber is deployed to each premise, Home Run Fiber requires the installation of much more fiber than other options, with each fiber running the entire distance between the subscriber and the CO.

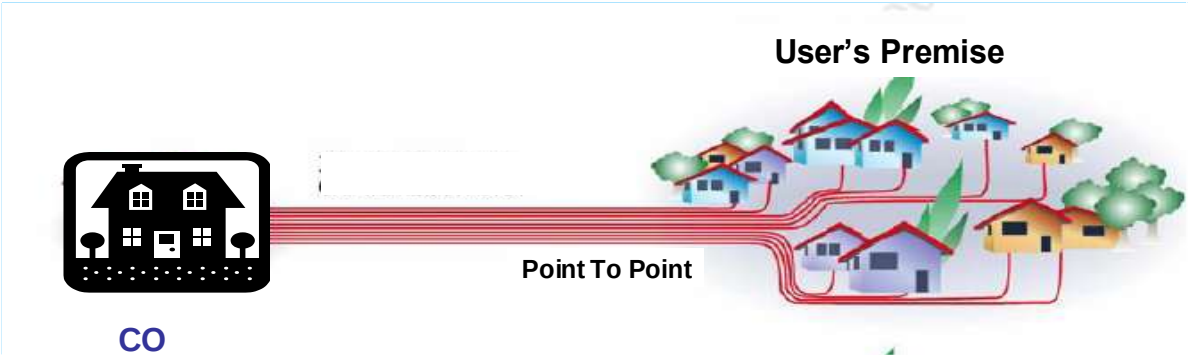


Fig. 4 Home Run Fiber (Point-to-Point) architecture

6.5.1.2 Active Star Ethernet (Point-to-Multi Point) Architecture

Active Star Ethernet (ASE) architecture is a point-to-Multi-point architecture in which multiple premises share one feeder fiber through a Ethernet switch located between the CO and the served premises.

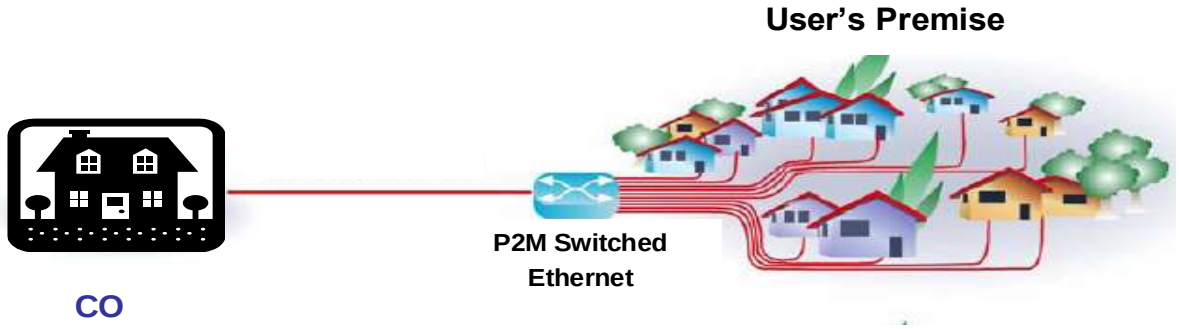


Fig. 5 Active Star Ethernet (ASE) architecture

With Active Star Ethernet (ASE) architecture, end users still get a dedicated fiber to their location; however, the fiber runs between their location and Ethernet switch. Like Home Run Fiber, subscribers can be located as far away from the Ethernet switch and each subscriber is provided a dedicated "pipe" that provides full bidirectional bandwidth. Active Star Ethernet reduces the amount of fiber deployed; lowering costs through the sharing of fiber.

6.6 PASSIVE OPTICAL NETWORK (POINT-TO-MULTIPOINT) ARCHITECTURE

The key interface points of PON are in the central office equipment, called the OLT for optical line terminal, and the CPE, called ONU for optical network unit (for EPON) and ONT for optical network terminal (for GPON). Regardless of nomenclature, the important difference between OLT and ONT devices is their purpose. OLT devices support management functions and manage maximum up to 128 downstream links. In practice, it is common for only 8 to 32 ports to be linked to a single OLT in the central office. On the other hand the ONT (or ONU) devices in the CPE support only their own link to the central office. Consequently, the ONT/ONU devices are much less expensive while the OLTs tend to be more capable and therefore more expensive.

6.6.1 OLT:

The OLT resides in the Central Office (CO). The OLT system provides aggregation and switching functionality between the core network (various network interfaces) and PON interfaces. The network interface of the OLT is typically connected to the IP network and backbone of the network operator. Multiple services are provided to the access network through this interface,.

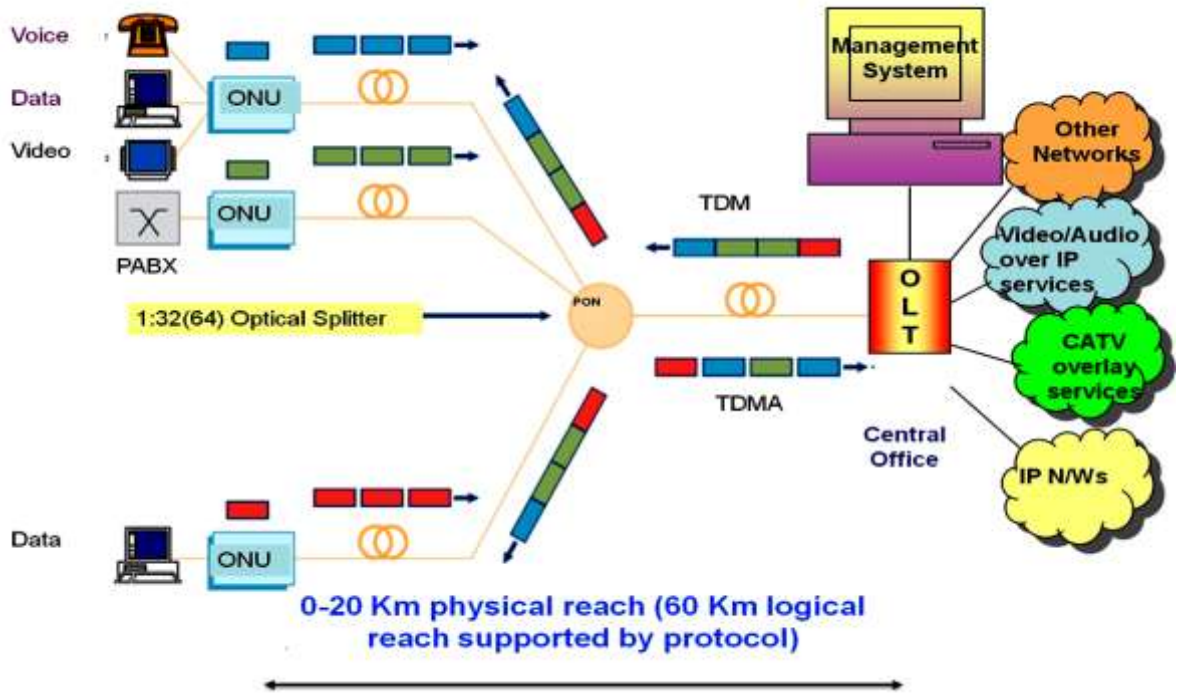


Fig. 6 PON Architecture

6.6.2 ONU/ONT:

This provides access to the users i.e. an External Plant / Customer Premises equipment providing user interface for many/single customer. The access node installed within user premises for network termination is termed as ONT. Whereas access node installed at other locations i.e. curb/cabinet/building, are known as ONU. The ONU/ONT provide, user interfaces (UNI) towards the customers and uplink interfaces to uplink local traffic towards OLT.

6.6.3 PON:

Distributed or single staged passive optical splitters/combiners provides connectivity between OLT & multiple ONU/ONTs through one or two optical fibers. Optical splitters are capable of providing up to 1:64 optical split, on end to end basis. These are available in various options like 1:4, 1:8, 1:16, 1:32 and 1:64.

6.6.4 NMS:

Management of the complete PON system from OLT.

- One OLT serves multiple ONU/ONTs through PON
- TDM/TDMA protocol between OLT & ONT
- Single Fiber/ Dual Fiber to be used for upstream & downstream
- Provision to support protection for taking care of fiber cuts, card failure etc.
- Maximum Split Ratio of 1:64
- Typical distance between OLT & ONT can be greater than 15Km (with unequal splitting - up-to 35Km)
- Downstream transmission I.e. from OLT to ONU/ONT is usually TDM
- Upstream traffic I.e. from ONU/ONT to OLT is usually TDMA
- PON system may be symmetrical or asymmetrical
- PON and fiber infrastructure can also be used for supporting any one way distributive services e.g. video at a different wavelength

PON is configured in full duplex mode in a single fiber point to multipoint (P2MP) topology. Subscribers see traffic only from the head end, and not from each other. The OLT (head end) allows only one subscriber at a time to transmit using the Time Division Multiplex Access (TDMA) protocol. PON systems use optical splitter architecture, multiplexing signals with different wavelengths for downstream and upstream.

6.7 SPLITTER CONFIGURATIONS

There are two common splitter configurations are being used for PON architecture i.e. **centralized and the cascaded** approaches.

6.7.1 CENTRALIZED SPLITTER APPROACH

In Centralized Splitter Approach typically uses a 1x32 splitter in an outside plant enclosure, such as a fiber distribution terminal. In the case of a 1x32 splitter, each device is

connected to an OLT in the central office. In this approach, optical splitters are concentrated in a single location from which all customer's optical network terminals (ONTs) at 32 homes are connected as shown in fig. 7.

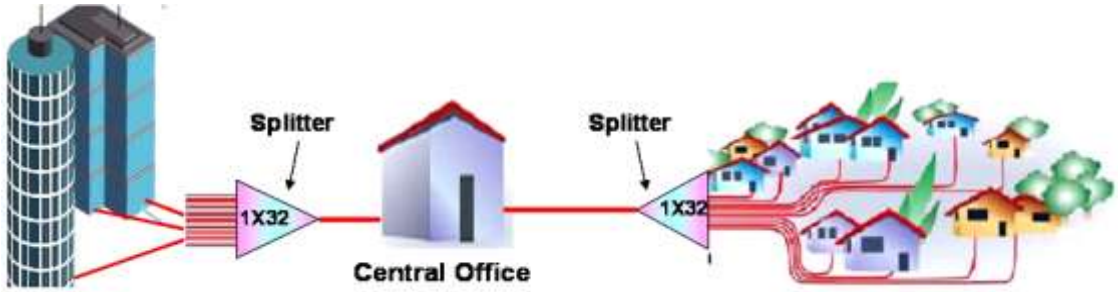


Fig. 7 Centralized Splitter Approach

6.7.2 CASCADED SPLITTER APPROACH

A cascaded split configuration results in pushing splitters deeper into the network as shown in fig.8. Passive Optical Networks (PONs) utilize splitter assemblies to increase the number of homes fed from a single fibre. In a Cascaded PON, there will be more than one splitter location in the pathway from central office to customer. Currently, standard splitter formats range from 1 x 2, 1 x 4, 1 x 8, 1 x 16 and 1 x 32 so a network might use a 1 x 4 splitter leading to a 1 x 8 splitter further downstream in four separate locations. Optimally, there would eventually be 32 fibers reaching the ONTs of 32 homes.

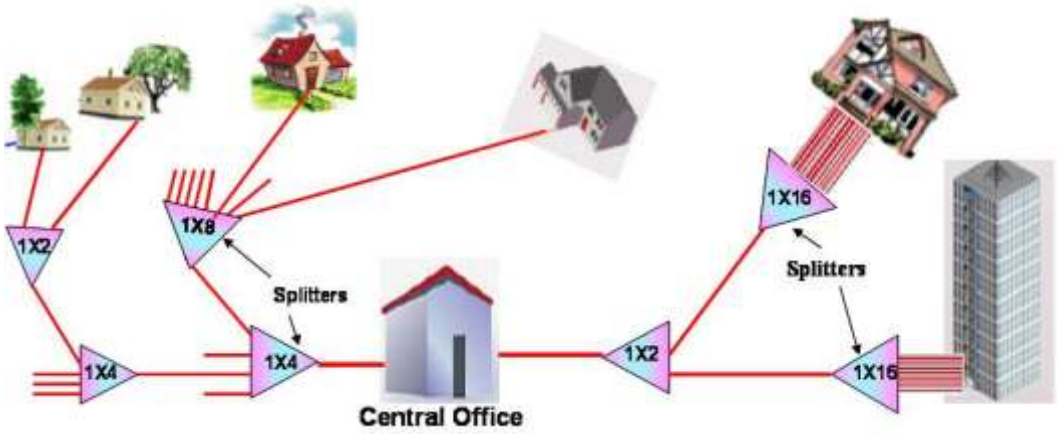


Fig.8 Cascaded Splitter Approach

There are several "flavors" of PON technology, i.e. new access technology named **APON** (ATM Passive Optical Network), **BPON** (Broadband Passive Optical Networking), **EPON** (Ethernet Passive Optical Networking) and **GPON** (Gigabit Passive Optical Networking) which delivers gigabit-per-second bandwidths while offering the low cost and reliability.

6.7.3 APON

ATM PON (APON) was standardized by the ITU in 1998 and was the first PON standard developed. It uses ATM principles as the transport method and supports 622 Mbps downstream services and 155 Mbps upstream service shared between 32-64 splits over a maximum distance of 20 km.

6.7.4 BPON

Shortly after APON, Broadband PON (BPON) followed and is very similar to APON. BPON also uses ATM, but it also boasts superior features for enhanced broadband services like video. BPON has the higher performance numbers then APON pre-splitting maximum of 1.2 Gbps downstream and 622 Mbps upstream.

6.7.5 EPON

The IEEE standardized Ethernet PON (EPON) in the middle of 2004. It uses Ethernet encapsulation to transport data over the network. EPON operates at rates of 1.25Gbps both downstream and upstream (symmetrical), using 8B/10B encoding over a maximum reach of 20. EPON is also called now as Gigabit Ethernet PON (GE-PON). It is defined as a single fiber network using Wavelength Division Multiplexing (WDM) operating at a wavelength of 1490 nm downstream and 1310 nm upstream. This leaves the 1550 nm window open for other services, such as analog video or private WDM circuits.

6.8 GPON

Gigabit PON (GPON) is the next generation of PON's from the line of APON and BPON. The ITU has approved standard G.984x for it. GPON will support both ATM and Ethernet for Layer 2 data encapsulation so is clearly an attractive proposition. GPON supports two methods of encapsulation: the ATM and GPON encapsulation method (GEM). GEM supports a native transport of voice, video, and data without an added ATM or IP encapsulation layer. GPONs support downstream rates as high as 2.5 Gbits/sec and an upstream rate from 155 Mbits/sec to 2.5 Gbits/sec. BSNL is procuring the GPON that will support downstream rate 2.5Gbps and upstream 1.25 Gbps.

6.9 THE FEATURES OF DIFFERENT PON STANDARD

Features	**BPON**	**GPON**	**EPON**
Responsible Standard body	FSAN & ITU-T SG15 (G-983 Series)	FSAN & ITU-T SG15 (G-984 Series)	IEEE 802.3ah
Bandwidth	Down Stream up to 622 Mbps Up Stream up to 155.52 Mbps	Down Stream up to 2.5 Gbps Up Stream up to 2.5 Gbps	Down Stream up to 1.25 Gbps Up Stream up to 1.25 Gbps
Downstream ג	1490 nm & 1550 nm	1490 nm & 1550 nm	1490 nm
Upstream ג	1310 nm	1310 nm	1310 nm
Layer-2 Protocols	ATM	ATM, Ethernet, TDM over GEM	Ethernet
Frame	ATM	GPON Encapsulation Method	Ethernet Frame
Max. Distance (OLT to ONU)	20 km	20 Km(supports logical reach up to 60 Km)	10 and 20 Km.
Split Ratio	1:16, 1:32 and 1:64	1:16, 1:32 and 1:64	1:16 and 1:32
Line Codes	NRZ (Scrambled)	NRZ (Scrambled)	8B/10B

Downstream Security	**AES:** Advanced Encryption Standard -128 bit key	**AES:** Advanced Encryption Standard (Counter mode)	Not Defined
FEC	None	Yes	Yes
No. of fibers	1 or 2	1 or 2	1
Protection Switching	Support multiple protection configuration	Support multiple protection configuration	None

6.10 PROPOSED SERVICES ON FTTH NETWORK OF BSNL

The first and foremost service proposed in the deployment of these PON technologies is to roll out the **Next Generation Play Network (NGPN).** The following services are proposed on the FTTH network:

- Basic internet Access Service controlled and uncontrolled from 256Kbps to 1000Mbps.
- TV over IP Service (MPEG2).
- Video on Demand (VoD)(MPEG4) play like VCR.
- Audio on Demand Service
- Bandwidth on Demand (User and or service configurable)
- Remote Education
- Point to Point and Point to Multi Point Video Conferencing, virtual classroom.
- Voice and Video Telephony over IP: Connection under control of centrally located soft switches.
- Interactive Gaming.
- Layer 3 VPN
- VPN on broadband
- Dial up VPN Service
- Virtual Private LAN Service (VPLS)

6.11 CONCLUSION

From the BSNL network point of view GPON, being the TDM based technology, shall integrate into the existing switching network. While the VOIP feature in the GE-PON provides easy migration path to the **Next Generation Network (NGN)** of the BSNL. GPON and GE-PON are the most suitable PON technologies for BSNL.

7 SATCOMM

7.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Concept of Satellite Communication
- Advantages of Satellite Communication
- Application areas
- Concept of VSAT

7.2 INTRODUCTION

Long distance communication using conventional techniques like coaxial cable or microwave radio relay links involves a large number of repeaters. For radio relay links of repeater spacing is limited by line of sight and is of the order of tens of kms. As the number of repeaters increase system performance and reliability are degraded. Tropo scatter propagation can cover several hundred kms.but the channel capacity is limited and costs are high due to necessity of large antennas and high transmit power. HF communication is subject to fading due to ionospheric disturbances and channel capacity is severely restricted due to limited bandwidth available. Large areas could be covered if the height of microwave repeater could be increased by putting it on board an artificial earth satellite. A **Communications satellite** (sometimes abbreviated to **COMSAT**) is an artificial satellite stationed in space for the purpose of telecommunications. Modern communications satellites use a variety of orbits including geostationary orbits, other elliptical orbits and low (polar and non-polar) Earth orbits.

For fixed (point-to-point) services, communications satellites provide a microwave radio relay technology complementary to that of submarine communication cables. They are also used for mobile applications such as communications to ships, vehicles, planes and hand-held terminals, and for TV and radio broadcasting, for which application of other technologies, such as cable, is impractical or impossible. In October 1945 Clarke published an article titled "Extra-terrestrial Relays" in the British magazine Wireless World. The article described the fundamentals behind the deployment of artificial satellites in geostationary orbits for the purpose of relaying radio signals. Thus Arthur C. Clarke is often quoted as being the inventor of the communications satellite.

7.3 GEOSTATIONARY ORBIT

A satellite in a geostationary orbit appears to be in a fixed position to an earth-based observer. A geostationary satellite revolves around the earth at a constant speed once per day over the equator. This satellite revolves above the equator round the earth at a height of 35,790 km. Its period of revolving round the earth is same as that of the earth rotation on its own axis. The geostationary orbit is useful for communications applications because ground based antennas, which must be directed toward the satellite, can operate effectively without the need for expensive equipment to track the satellite's motion. Especially for applications that require a large number of ground antennas (such as direct TV distribution), the savings in ground equipment can more than justify the extra cost and onboard complexity of lifting a satellite into the relatively high geostationary orbit.

In October 1945 Clarke published an article titled "Extra-terrestrial Relays" in the British magazine Wireless World. The article described the fundamentals behind the

deployment of artificial satellites in geostationary orbits for the purpose of relaying radio signals. Thus Arthur C. Clarke is often quoted as being the inventor of the communications satellite.

The first truly geostationary satellite launched in orbit was the Syncom 3, launched on August 19, 1964. It was placed in orbit at 180° east longitude, over the International Date Line. It was used that same year to relay experimental television coverage on the 1964 Summer Olympics in Tokyo, Japan to the United States, the first television transmission sent over the Pacific Ocean.

A geostationary satellite is launched above the equator 36,000 km high above the earth. Its period round the earth coincides with that of the earth rotation. Therefore, the satellite looks as if it is stationary from the earth. If three (3) communication satellites are launched equidistantly above the equator, it can serve almost all communication network round the world.

For a geostationary satellite, the following orbital conditions must be satisfied:

- Period of revolution should be same as period of the earth's rotation which is 23 hours 56 minutes and 4 seconds.
- The altitude of the satellite should be 35786 km as per the Kepler's third law.
- The orbit should be in equatorial plane of the earth.
- The satellite should move in the easterly direction same as the direction of rotation of the earth.

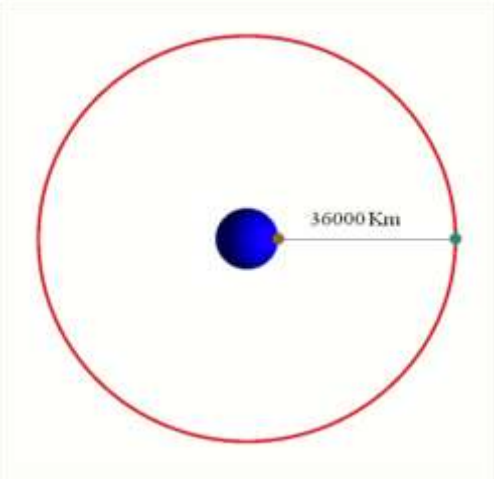


Figure 1: Geostationary orbits

This satellite is advantageous because:

Its large antenna at an earth station is easy to track.

(1) Twenty–four (24) hours communication can be made with even only one satellite.
(2) The satellite looks at the earth as if it were stationary, and it radiates highly effective wave power.
(3) Visibility from one satellite is very wide, and global communication can be made using only three satellites.

Its drawback, however, is its delay caused in long distance transmission. But, the system is economical and accordingly, it is widely used for both international and regional domestic communications.

7.4 ADVANTAGES OF SATELLITE COMMUNICATIONS

(i) **Large coverage :** Almost one–third of the earth with exception of polar regions is visible from geostationary orbit. It is, thus, possible to cover about 10,000 kms. distance irrespective of intervening terrain with a single satellite.

(ii) **High quality :** Satellite links can be designed for high quality performance. The link performance is highly stable since it is free from ionospheric disturbances, multipath effects or fading.

(iii) **High reliability :** Reliability is high since there is only one repeater in the link.

(iv) **High capacity :** With microwave frequencies, wide bandwidths are available and large communication capacity can be obtained.

(v) **Flexibility :** In a terrestrial system, communication is tied down to the links installed. On the other hand, satellite communication is well suited for changing traffic requirements, locations and channel capacities.

(vi) **Speed of installation :** Installation of earth terminals can be achieved in a short time as compared to laying of cables or radio relay links.

(vii) **Mobile, short–term or emergency communications:** With ariliftable or road transportable terminals, short–term or emergency communications can be quickly provided. Reliable long distance land mobile, maritime mobile and aeronautical mobile services are feasible only by means of satellite.

(viii) Satellite communication is ideally suited for point to multipoint transmission on broadcasting over large areas. Application of satellites for TV broadcasting, audio and video distribution and teleconferencing, facsimile, data and news dissemination is, therefore, increasing rapidly.

7.5 APPLICATIONS AREAS:

7.5.1 TELEPHONY

The first and historically most important application for communication satellites was in intercontinental long distance telephony. The fixed Public Switched Telephone Network relays telephone calls from land line telephones to an earth station, where they are then transmitted to a geostationary satellite. The downlink follows an analogous path. Improvements in submarine communications cables, through the use of fiber-optics, caused some decline in the use of satellites for fixed telephony in the late 20th century, but they still serve remote islands.

7.5.2 SATELLITE TELEVISION

Television became the main market, its demand for simultaneous delivery of relatively few signals of large bandwidth to many receivers being a more precise match for the capabilities of geosynchronous comsats.

7.5.3 FIXED SERVICE SATELLITE

Fixed Service Satellites use the C band, and the lower portions of the K_u bands. They are normally used for broadcast feeds to and from television networks and local affiliate stations (such as program feeds for network and syndicated programming, live shots, and backhauls), as well as being used for distance learning by schools and universities, business television (BTV), Video conferencing, and general commercial telecommunications. FSS satellites are also used to distribute national cable channels to cable television headends.

7.5.4 DIRECT BROADCAST SATELLITE

Direct broadcast satellites generally operate in the upper portion of the microwave K_u band. DBS technology is used for DTH-oriented (Direct-To-Home) satellite TV services, such as DirecTV, DISH TV etc. Operating at lower frequency and lower power than DBS, FSS satellites require a dish for reception (3 to 8 feet (1 to 2.5m) in diameter for K_u band, and 12 feet (3.6m) or larger for C band).

7.5.5 SATELLITE RADIO

Satellite radio offers audio services in some countries. Mobile services allow listeners to roam a continent, listening to the same audio programming anywhere.

7.5.6 SATELLITE INTERNET

After the 1990s, satellite communication technology has been used as a means to connect to the Internet via broadband data connections. This can be very useful for users who are located in very remote areas, and cannot access a broadband connection.

7.5.7 NAVIGATION

One of the fascinating applications of satellites is GPS (Global Positioning System). Its primary application is navigation. Receivers on the earth pick up transmissions from four satellites simultaneously. The receiver uses the microprocessor to compute and display the exact position, in terms of latitude and longitude

7.6 BASIC COMMUNICATIONS SATELLITE COMPONENTS

Every communications satellite in its simplest form (whether low earth or geosynchronous) involves the transmission of information from an originating ground station to the satellite (**the uplink**), followed by a retransmission of the information from the satellite back to the ground **(the downlink**). The downlink may either be to a select number of ground stations or it may be *broadcast* to everyone in a large area. Hence the satellite must have a receiver and a receive antenna, a transmitter and a transmit antenna, some method for connecting the uplink to the downlink for retransmission, and prime electrical power to run all of the electronics. The exact nature of these components will differ, depending on the orbit and the system architecture, but every communications satellite must have these basic components. This is illustrated in the drawing below.

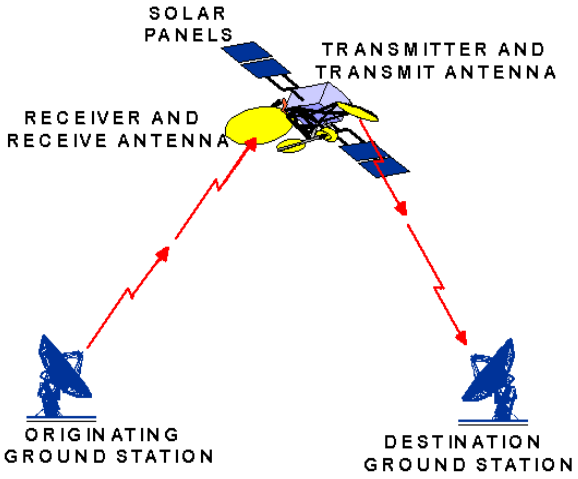


Figure 2: Basic Components of a Communications Satellite Link

The communication satellite essentially consists of

- Payload
- Support subsystems

Payload refers to the equipment used to provide the service for which the satellite has been launched. In communication satellites, payload consists of **transponders** which carry out the repeater function and the transmit and receive antennas. Support subsystems include altitude and orbit control equipment, power subsystem, telemetry and telecommand subsystem, etc.

7.7 FREQUENCY BANDS

Frequency bands in use for satellite communication are given in Table-5:

Table-1

"L" BAND	1830–2700 MHz
"S" BAND	2500–2700 MHz
"C" BAND	5925–6425 MHz UP 3700–4200 MHz DOWN
"X" BAND	7900–8400 UP 7250–7750 DOWN
"KU" BAND	14.000–14.500 Hz. UP 10950–11200 GHz/DN. 11450–11700 GHz/DN.

"K" BAND	27.5–30 GHz UP 17.7–21.2 GHz DOWN
EXTENDED C BAND	6725–7025 UP 4500–4800 DOWN
V BAND	40–51 GHz UP 40–41 GHz DOWN
V Band Inter-satellite	59–64 GHz 54–58 GHz

7.8 TIME DELAY

Transmission path of a communication link through a satellite is about 72000 km long (36000 km uplink path and 36000 km downlink path). Electromagnetic waves travelling at 3 x 10^5 km/sec take about 240 msec. from one end to the other. Such large propagation delay is at the limit of psychologically tolerable values in telephony. The propagation delay results in "echo" in a telephony channel. A special equipment called echo suppressors is incorporated in the earth station to counteract the echo. Propagation delay also restricts the number of satellite hops for building up a telephony circuit to one as the resulting propagation delay will be much beyond the acceptable value for more than one hop. Kinds and Systems of Communication Satellite

Kinds of Communication Satellites – depends on type of orbit and freq. band used.

During the early experimental stage of communication satellites, a passive satellite was used without any amplifiers and it only reflected radio waves sent from the earth station. But, later on active satellite with amplifiers was developed and put into practical use. Communication Satellite can be classified by the orbit used and also by frequency band used. Before discussing satellite orbits in a more generalized manner, however, it is necessary to be aware of the natural laws that control the movement of satellites. These are based on Kepler's laws and basically stated are:

(i) The orbit plane of any earth satellite must bisect the Earth centrally.

(ii) The Earth must be at the centre of any orbit.

The choice of orbit is restricted to three basic types, namely : **polar, equatorial and inclined** as illustrated in Fig.3. The actual shape of the orbit is limited to circular and elliptical. Any combination of type and shape is possible but observations are made only of the circular polar, elliptically inclined and the circular equatorial.

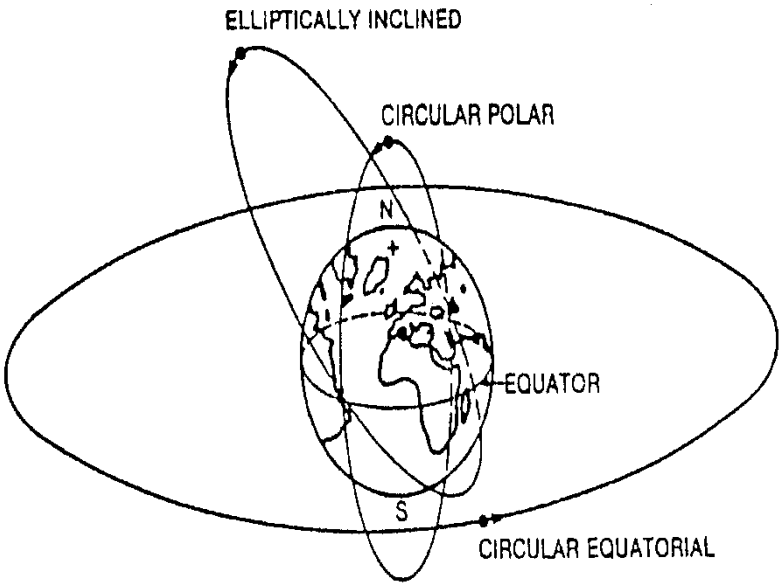


Figure 3: Three Basic Orbits

7.8.1 CIRCULAR POLAR ORBIT

This is the only orbit that can provide full global coverage by one satellite, but requires a number of orbits to do so. In a communications sense where instantaneous transfer of information is required, full global coverage could be achieved with a series of satellites, where each satellite is separated in time and angle of its orbit. However, this produces economic, technical and operational disadvantages and is thus not used for telecommunications though it is favored for some navigation, meteorological and land resource satellite system.

7.8.2 ELLIPTICALLY INCLINED ORBIT

An orbit of this type has unique properties that have been successfully used for some communications satellite system, notably the Russian domestic system. For this system, the elliptical orbit has an angle of inclination of 63 degrees and a 12–hour orbit period. By design, the satellite is made to be visible for eight of its 12–hour orbit period to minimize the handover problem while providing substantial coverage of the temperate and polar regions. By using three satellites, suitably phased, continuous coverage of particular temperate region can be provided that would not be covered by other orbits.

The elliptically inclined orbit is used exclusively by the Russians for their Orbital and Molniya systems, but since coverage is limited to particular areas (higher latitudes), it is, therefore, not suitable for a global network.

7.8.3 CIRCULAR EQUATORIAL ORBIT

Circular orbits in the equatorial plane permit fewer satellites and ground stations to be used, and satellites with long orbital periods (at high altitudes) have greater mutual visibility. A satellite in a circular orbit at 35,800 km has a period of 24 hours and consequently appears stationary over a fixed point on the earth's surface. The satellite is visible from one third of the earth's surface, up to the Arctic circle, and this orbit is almost universally preferred for satellite communications system**.**

7.9 V-SAT

VSAT stands for Very Small Aperture Terminal. VSAT is a device (also known as an "earth station") that is used to send and receive wireless transmissions by satellite. Millions of VSATs are in use around the world, allowing people to send and receive two-way data, voice or video transmissions by bouncing signals off of satellites in orbit.

The "very small" component of the VSAT acronym refers to the size of the VSAT "antenna" or "dish" - typically about 2 to 5feet (0.55-1.8 meters) in diameter for Ku-band systems - that is mounted on a roof, attached to a wall or placed on the ground and is capable of both receiving and sending satellite signals. VSAT systems can be designed to serve both broadcast and interactive applications whether data, voice or video, which are now being served by terrestrial lines and can be operated in either single or multi-user environment

VSAT Equipment is mainly consist of-

- ODU (Outdoor Unit)
- IDU (Indoor Unit)

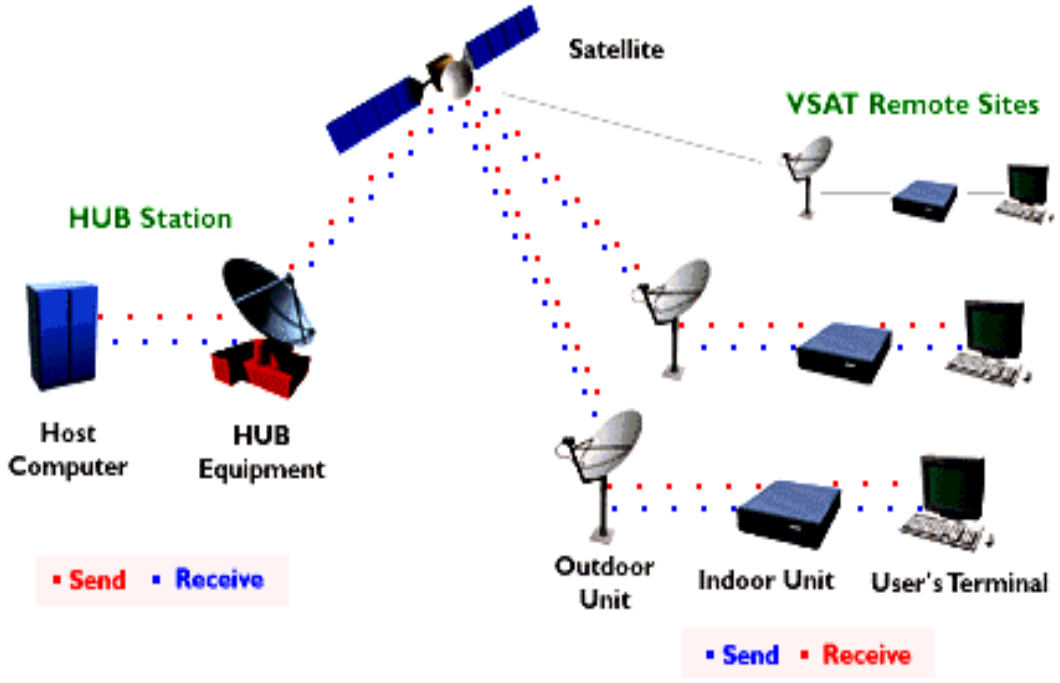


Figure 4: VSAT Network

7.9.1 Outdoor Unit (ODU):

The outdoor unit system is specifically optimized for use with the Indoor Unit and consists of:

- Transmit / Receive Dish (Antenna) (0.75m - 1.8m)
- Block Up-converter (BUC) (1W-2W)
- Low Noise Block-Down-converter (LNB)
- Feed Assembly

BUC: - Block up-converter converts incoming I.F. (from IDU) to R.F. transmitting frequency, amplifies it and passes it to feed.

LNB: - LNB amplifies incoming R.F.(Radio Frequency) from feed using low noise amplifier, converts it to I.F. and passes it to IDU

7.9.2 IDU (Indoor Unit):

On receiving side, converts I.F. (Intermediate Frequency) from ODU to base band signals which may be data, video or voice. On transmitting side, converts base band signals to I.F. and passes them to ODU. I.F. is generally in L band. R.F. can be in C, Ku or Ka bands.

The indoor unit may be a small desktop box, or it may be (as in this case) a network module integrated with a router providing VSAT network connectivity just as any other network module and provide flexible Interfaces like Ethernet 10/100 BaseT (RJ45), USB with maximum download speed of up to 4 Mbps and maximum upload speed of up to 2 Mbps.

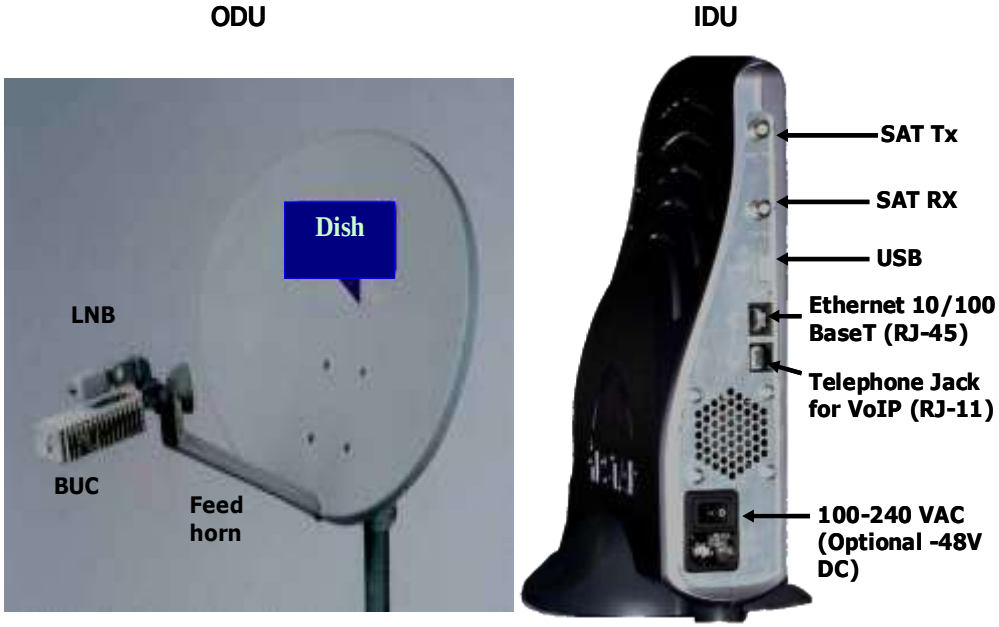


Figure 5:ODU & IDU

VSAT Broadband (Ku band VSAT) networks of BSNL designed in a hub-and-spoke arrangement with customer locations connecting directly over the air to a central "hub" facility. The equipment at a customer site is a VSAT receiver/router (similar to a DSL or cable modem), attached to a small dish mounted on top of or outside the building. At the central hub facility, a large dish and sophisticated hub RF components receive and transmit to the remote sites, and route information to and from the Internet or private networks via leased line.

BSNL's Ku Band HUB (Earth Station) at BANGALORE consists of :

- Satellite antenna of 8.1 m – Casse grain feed type.
- Ku Band RF equipment and its control systems.
- GATEWAY Networking Equipment with interfaces to Terrestrial Networks like MLLN, MPLS and NIB.

7.10 CONCLUSION

Satellite Communication utilization has become wide spread and ubiquitous throughout the country for such diverse applications like Television, DTH Broadcasting, DSNG and VSAT to exploit the unique capabilities in terms of coverage and outreach. The technology has matured substantially over past three decades and is being used on commercial basis for a large number of applications. Most of us are touched by satellite communication in more ways than we realized.

A recent trend in digital satellite communication systems is to apply the powerful FEC code with large coding gain to use the limited satellite power as efficiently as possible. Since the usable frequency band is also becoming severely limited, it is more desirable to apply the FEC code of high coding rate with high coding gain.

VSAT technology is a secure and reliable medium to connect geographically dispersed locations and represents a cost effective solution for users seeking an independent communication network connecting to the global network. In a situation where other connectivity options are not feasible, broadband VSAT of BSNL (operating in Ku band of electromagnetic spectrum i.e. 11 to 18 GHz) offer value added satellite based services capable of supporting- Broadband internet access, VOIP, video conferencing, IP multicast, Local Area Network, voice, Fax and can also provide powerful dependable private communication solutions.

8 CLOSED USER GROUP & CENTREX

8.1 LEARNING OBJECTIVES

At the end of session, the trainees will be able to

- Explain the concept of Centrex
- Understand the salient features of Centrex
- Understand the new NGN based IP Centrex
- Understand the features of IP Centrex

8.2 INTRODUCTION:

A group of users may form themselves into a CUG, creating a Pseudo "Private" sub-networking, utilizing the facilities of the network. This service enables the subscribers belonging to the same CUG to make communications with each other preventing access from or to the world outsidethe group.

The CUG has opened up newer channels of communication for the upwardly mobile, heavy duty user. An organization with CUG would be like a giant EPABX Exchange over the whole country. CUG is a facility, wherein a group of subscribers within an organization can talk (or send messages) to each other at a differential cost or for free, thereby significantly reducing the overall cost of communication for the company.

The service can also be customized as per the requirement of the client. In this case subscribers are tied in a pre-specified loop whereby they can send or receive message to all users in the group, at one turn. The configurations of the user-group numbers are captured in thesystem at the service center to facilitate the benefits of CUG.

Service providers these days are vying with each other to woo more customers for CUG by providing more STD operating procedures ex caller identifications, call forwarding are some of the options that come free with CUG package. Corporate plans are cheaper, convenient and come with more utilities.

8.3 CENTREX

Centrex is a communication service which is available at centrally in an organization, integrates many landline telephone numbers into a single functional group with many features having free calling at any time in that landline group without any extra equipment with new tariff at lowest rates. Centrex is the facility under which landline customers can talk free of cost with each other,within a group.

BSNL Landline Group Plan, connects all the telephone numbers of old and new into one group, connecting each number with free calling at any time without any extra registration amount, initial deposit, and installation charges.

For Centrex facility, there is no limit for members to join into the same centrex group, and the customers who avail this Centrex facility will be allowed to get free calls as usually according with normal plan along with free calling between the group numbers. According with technical feasibility, BSNL offers consolidated billing, payment and discount, under the

"Corporate Account Holders Scheme" where applicable, may be provided to the groups or organizations covered under the Centrex.

8.3.1 The Salient features of Centrex facilities:

- The existing customer can opt for this facility and new customers can avail this facility atthe time of booking of telephone connection.
- Minimum limit of members in a group of Centrex would be five.
- Calls within the Group are free.
- The registration amount, initial Deposit, monthly rental and installation charges etc. for Telephone Connection under Centrex shall be same as normal Telephone connection.
- The free monthly calls as per tariff plan shall be allowed on the telephone connection covered under the Centrex.
- Anybody can join/leave the existing Group at any time.
- The numbers belonging to public Services like, call Centers, enquiry numbers, ISP Dial in numbers, paging service numbers, franchises, PCO holders and only incoming number shall not be part of the Centrex Group.
- Centrex Facility will be available in all Tariff Plans.
- The Free Centrex facility shall be for the Cooperative Group Housing Society/Resident Welfare Associations and DDA having clearly defined boundaries with maximum 500 dwelling units. Above 500 dwelling units the case will be considered by the concerned CGMs on case to case basis.
- This scheme is restricted to the Members of Society residing within the same premises. No additional rent will be charged from the Members for availing Centrex facility. There will not be any security deposit, Registration/Installation charges. However usage charges shall be made by the Society. This free Centrex facility will also be extended to Shopping malls with well defined boundaries with minimum 10 users.

Salient Features of CENTREX Subscriber

a. CLIP for Intercom and network calls
b. Conditional call forward On busy call, On no reply, Only PSTN calls, Only Intercom calls
c. Call pick up Within Group, Directed, Night Service
d. Call Transfer Features All Calls, Incoming calls only, Internal only
e. Voice/Data protection

In CENTREX, no physical PABX needs to be installed. Facility can be extended to any ordinary telephone. A special dial tone which is different from the normal dial tone is provided.A number of such lines can form a group called CENTREX group.

Like a PABX, following dialing procedure is adopted:

a. For internal call (call within the group), dial a 2 or 3 digit number.
b. For outgoing call (to call outside the group), dial '9' - get normal dial tone-dialLocal/STD/ISD digits.

c. For incoming call - a CENTREX number can be reached from outside the group bydialing the 7 or 8 digit directory number.

8.3.2 CENTREX FACILITY FOR CIC/CORPORATE CUSTOMERS

A. CENTREX FACILITY IN THE BSNL NETWORK FOR CIC/CORPORATE CUSTOMERS:

(i) The charges for Centrex facility are available on the site bsnl.co.in. The Centrex charges will not be levied for CIC/Corporate customer whose annual revenue is more than Rs. 4 lakhs with combined billing wherever technical feasible.

(ii) Centrex facility may also be allowed to the trade related groups, which are identified/authorized by respective associations like medicine, hardware, sanitary, doctors, lawyers and general store etc. within SDCA after charging the Centrex charges.

B. RENT FREE INCOMING CONNECTION:

Rent free connection for corporate customers, housing societies multistory complex etc. may also be provided for the use of incoming calls and making calls to other Centrex numbers subject to the fulfillment of following conditions:

TABLE -1 CENTREX SIZE AND ITS RENT FREE CONNECTION

Size of Centrex Group	Rent free incoming connection
15-25	01
26-50	02
51-100	03
For every additional 100 connections	1 additional connection in additionabove

Note:

i. The security deposit, fixed monthly charges, installation charges, free calls etc shall be same as applicable to normal DEL.
ii. All intra centrex calls shall be free.
iii. The free monthly call shall be allowed on the DELs covered under the centrex.
iv. There is no upper limit on the number of members in the centrex group.
v. The Dels belonging to public services like, call centers, enquiry numbers, ISP Dial in numbers, paging service numbers, PCO holders shall not be part of the Centrex group.

(C) Centrex facility to trade related group, which are identified/authorised by respective associations like medicine,Hardware,Sanitary,Doctors,Lawyers and General Store etc.

TABLE-2 CENTREX GROUP PLANS

Size of the Centrex Group	**Monthly plan charges for Intra circle (in Rs.)**	**Monthly plan charges for Inter circle (in Rs.)**	**Monthly plan charges for SDCA (in Rs.)**
Less than 25	75	150	50
More than 25	90	180	60

Note:

- Rental for Centrex will be based on number of connections within the group and category of Centrex.
- There will be possibility of change of Category.
- IP Centrex will be offered on fixed rental basis to the customers
- Subscriber will not be charged for per call (both local &STD) within Centrex
- IP Centex services will be provided to both Post and Prepaid subscribers
- Plan/rental would be applied on individual subscriber
- Even if some of subscriber moves out of group , the slab will not change.

8.4 WINGS Closed User Group(All India IP Centrex)

A user can setup a WINGS closed user group across the country with both fixed line and mobile users of BSNL as members of the group. The users include both NGN and Non NGN customers of BSNL. This facility can be availed after paying a nominal charge per month per user of IP Centrex facility. It allows small and medium size enterprises to deploy PABX/ CUG service without really installing a system physically in their premises. You can have a PAN India IP centrex i.e. numbers anywhere in the country can be brought into a single Centrex group.

Wings Closed Used Group (IP Centrex):-

Features of IP Centrex

i. Master number can be any BSNL landline no.
ii. IP Centrex group may have 10000 members in a group. For creation of IP Centrex group for more than 10000 NCNGN Circle may be contacted through EB Cell/Circle.
iii. Intra SDCA is applicable to landline number only as part of group. (Useful for apartment, group housing society, colony etc.)
iv. Call made by full number dialing instead of short dialing will be charges as per existing landline or mobile plan.
v. GSM mobile customers can make Centrex calling as Access code 1286(1261-Old Code) + Short code.
vi. For GSM Mobile customers while roaming no additional charge for Centrex calling if possible.
vii. Sulabh connection can be part of group (on request) but cannot be master of the IP Centrex group.

viii. Billing/deduction of rental is to be from respective prepaid and postpaid account of individual group number but in case of default billing to be borne by master number.

ix. It will be responsibility of applicant to ensure group numbers provided their consent to be part of IP Centrex Group.

8.4.1 IP Centrex Features

- IP Centrex allows small and medium size enterprises to deploy PABX/ CUG service without really installing system physically in their premises.
- IP Centrex have no limitation of Zone . It is PAN India Service.
- A customer can have a PAN India IP centrex i.e. numbers anywhere in the country can be brought into a single Centrex group. Each member of the group can access the other by dialing a short code.
- The IP centrex supports different types of terminals of the enterprise in the same group, such as mobile terminals, landline phones.
- Number Presentation/CLIP of intra-CENTREX call is the short number.
- Dialing with the long number is recognized as off-net call, even if the caller and callee are Centrex users and in the same group.
- It works between NGN, PLMN and 5ESS and EWSD PSTN Subscribers.
- A CENTREX Group can have max 10,000 subscribers.
- Customer can request for any short code range except starting with 0 ,1 and 9.
- If a BSNL mobile subscriber roams to other operator's network, he can't use the Centrex service.

8.4.2 IP Centrex Group Categories

- Within STD Code/City/Apartment
- Within SSA
- Within Circle
- Within Zone
- Across the Zones
- Number Within Group may be from Different Zones and from different Services like LL,GSM.

8.4.3 The Centrex dialing method

- Centrex Short Code length is 3 to 5 digits.
- Landline Customer will dial short code to access the LL/Mobile number of the same group. Mobile Customer will dial 1261 +Short code to access the LL /Mobile number of the same Group.

How to Get IP Centrex?

- Customers can Get the IP Centrex service through SMS/E-mail/IVRS/BSNL Portal/BSNL CSC/Call Centre.
- Any customer requiring this service has to submit the list of numbers (LL/Mobile) to be added to IP Centrex Group. Fill up the CAF, selecting IP Centrex category and has to submit it to CSR/EB with required documents
- Sending SMS request for IPCENTREX Service requests Format is : IPCENTREX followed by STD code i.e IPCENTREX <space><std code> to 54141. SMS is pushed to Call Centre. Call Centre agent speaks to customer and raises request on CRM.
- Fault handling mechanism: Subscribers can book service request / complaint through 1500/198.

8.5 Conclusion :

It is central office based communication service, which integrates all your multi located telephone lines (Existing and New) into a single highly functional communication groupwith more distinctive features without any additional equipment (like EPABX) at your premises. Highly cost effective, Free Intra Centrex calls, No worry to select innovative (PBXs) equipment,No risk of obsolescence of technology, No requirement of power supply, No need to waste valuable floor space, No annual maintenance charges, totally flexible are some of the salient features of Centrex facility.

9 ADSL TECHNOLOGY AND BB SERVICES

9.1 LEARNING OBJECTIVE

In this chapter broad band ADSL is covered. After reading this chapter, the participants will be able to understand the concepts of ADSL technology, broad band architecture and its components and also the features and advantages of broad band technology.

9.2 What is Broadband?

TRAI has defined Broadband as an always on data connection that is able to support interactive services including internet access and has the capability of the minimum download speed of 512 kbps to an individual subscriber from the point of presence (POP) of the service provider intending to provide broadband service where multiple such individual broadband connection are aggregated and the subscriber is able to access these interactive services including the internet through this POP.

9.3 Advantages of Broadband

- ✓ Always on (Not on shared media)
- ✓ Fast (speed ranging from 512 kbps to 26Mbps)
- ✓ No disconnection
- ✓ No additional access charge Telephone and Data simultaneously
- ✓ Fat pipe has to be continuously supplemented with value added applications to enjoy the advantage.

9.4 Wired Broadband Technologies:

There are many different types of broadband access technologies. Each of these technologies can compete to provide similar services to consumers and businesses.

- ✓ Digital Subscriber Line (DSL, given over copper loop of Telecom operators)
- ✓ Cable Modem (CM, Given over cable TV operators coaxial cable network)
- ✓ Power Line Broadband (BPL, Over Power lines)
- ✓ Fiber technology

9.4.1 Digital Subscriber Line (DSL)

Digital Subscriber line (DSL) is a wire line transmission technology that brings data and information faster over copper telephone lines already installed in homes and businesses. Traditional phone service connects your home or business to a telephone company office via copper wires. A DSL modem accesses the local telephone company's central office where a DSL Access DSLAM then transmits the signal from the copper telephone line onto a network backbone, and eventually to the Internet. With high speed Internet access that uses DSL transmission technology, there is no need to "dial in" to a traditional modem. This

service allows consumers and business to have an "always-on" dedicated connection to the Internet. The following are types of DSL transmission technologies that may be used to provide high-speed Internet access.

xDSL

- Symmetric DSL
- Provide identical data rates upstream & downstream
- Asymmetric DSL
- Provide relatively lower rates upstream but higher rates downstream

Four main variations of xDSL exist:

- ADSL-Asymmetric Digital Sub's Line
- HDSL-High bit/data rate Digital Sub's Line
- SDSL-- Symmetric Digital Sub's Line
- VDSL-Very-high-data-rate Digital Sub's Line

9.4.1.1. ADSL

A. Used primarily by residential users who receive a lot of data but do not send much such as Internet surfers.

B. ADSL provides faster speed in a downstream direction (from the ISP office to the customer premises) than the upstream direction (i.e from customer premises to ISP office).

C. G.DMTG.992.1 standard

D. Used for applications which require greater download bandwidth but require relatively little in opposite direction like Web browsing.

E. An ADSL circuit connects an ADSL modem on one end of a twisted pair telephone line creating three information-channels

- A high speed downstream channel
- A medium speed duplex channel for both upstream & downstream applications
- A basic telephone service channel

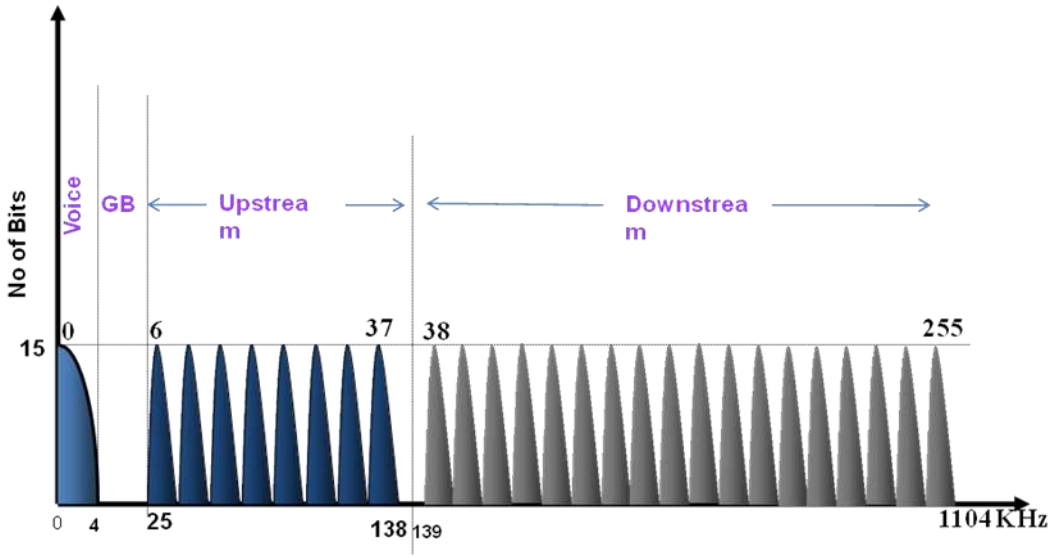


Fig 1: DMT Modulation

Table 1: ADSL Family

Family	Up stream Rate	Down stream Rate	Maximum range
ADSL	640 KBps	8 MBps	5.5 Km
ADSL Lite	384 KBps	2 MBps	6Km
ADSL2	1-1.5 MBps	12-16 MBps	5.7 Km
ADSL2 +	1 MBps	26 MBps	5.7 Km
ADSL2 RE	1MBps	12 MBps	7Km

9.4.1.2 ADSL 2

Offers a greater data rates of 15 Mb/s downstream and upto 1.5 Mb/s upstream with a range 6.4 Kms .

Has two power management modes (L2 mode for power saving at ATU-C by rapidly entering and exiting low power mode based on internet traffic over the connection) and L3 mode for overall power saving at both ATU-C and ATU-R by entering into sleep mode) that help reduce power consumption.

Supports seamless adaptation of data rate in real time to meet the changing line conditions.

Fast start up i.e. reduced initialization time from 10 secs to 3 secs.

Data rates can be increased by bonding multiple phone lines (2 or more copper pairs) together.

9.4.1.3 ADSL 2 +

Doubles max. frequency used for down stream data transmission from 1.1 Mhz to 2.2 Mhz.
Offers a greater data rates of 25 Mb/s downstream and upto 1.5 Mb/s upstream.
Can work upto 6.3 Kms with reduced data rates.
Has all the other benefits of ADSL 2 like improved power management, seamless adaptation of data rate in real time to meet the changing line conditions, bonding of copper pairs for higher data rates etc.

9.4.2. High-data-rate Digital Subscriber Line (HDSL)

It provides fixed symmetrical high speed access at T1 rate (1.5 Mbps), and is designed for business purposes.

9.4.3. Symmetrical Digital Subscriber Line (SDSL)

It is used typically for business applications such as video conferencing. The traffic from the user to the network is upstream traffic, and from the network to the user is downstream traffic. When the data rate in both directions is equal, it is called a symmetric service.

9.4.4. Very high-data-rate Digital Subscriber Line (VDSL)

Provides both symmetrical and asymmetrical access with very high bit rate over the copper line. Very-high-bit-rate digital subscriber line (VDSL or VHDSL, provides data rates up to 52 Mbit/s downstream and 16 Mbit/s upstream over copper wires and up to 85 Mbit/s down- and upstream on coaxial cable. VDSL is capable of supporting applications such as high-definition television, as well as telephone services (voice over IP) and general Internet access, over a single physical connection. The maximum data rate is achieved at a range of about 300 meters and performance degrades as distance and loop attenuation increases.

9.5. BSNL'S Broadband Access Technology

BSNL Broadband service is built on a world class, multi-gigabit, multi-protocol, convergent IP infrastructure through National Internet Backbone-II (NIB-II), that provides convergent services through the same backbone and broadband access network. In BSNL Asymmetric Digital Subscriber Line (ADSL) Technology is used for giving the Broadband connection where greater download is required in comparison to upload.

9.6. Effect of copper pair quality

Data speed capability depends on the thickness of wire used in cable network. Higher the gauge, higher the data carrying speed. Data speed deteriorates if copper loop quality is bad i.e. more joints, loose joints, low insulation etc.

9.7. For BSNL Broadband connection, Customer Needs:

i. BSNL's Landline connection
ii. Computer with 10/100 Mbps Ethernet CardDSL
iii. Modem + Splitter (CPE)

iv. PPPoE software to be loaded in the Client Broadband Account (Username and Password**)**

9.8. How BSNL Broadband is better than Cable Modem Service

High-speed Internet access that uses Cable Modem (internet service given by Cable TV operators) offers shared bandwidth or speed among neighbors on the same cable system. Speed is asymmetric and will vary depending on the number of people on the network. With high-speed Internet access that uses DSL service, one gets a dedicated connection to the home. In most cases, however, the performance of DSL based service depends on the distance between end user and phone company central office.

9.9. Services offered to BSNL Broadband customers

Basic internet Access Service controlled and uncontrolled (512Kbps to 1000Mbps) . BSNL has various tariff plans for home and business customers.

Content Based services: [Video on Demand (VoD), Education, Audio on Demand (AoD) etc.] BSNL has tied up with franchisees to offer this service. A set top box (STB) is provided which acts as the interface between ADSL modem and TV.

Web conferencing: BSNL has tied up with a franchisee to offer this service. Toll free number for knowing details is 1800-111-233. BSNL Web Conferencing Service enables to conduct virtual meetings with business partners, suppliers, employers etc. It has the innovative feature such as Persistent meeting rooms, which simulates physical room environment wherein authorized users can enter their designated rooms the way do in physical meetings.

The users can access the rich features, apart from multi-point, multi-media (Audio, Video & Data) conferencing service, BSNL web Conferencing serviceprovides very powerful data conferencing tools to enhance collaboration among users such as sharing of PowerPoint Presentation, Whiteboard, Documents, & Chat facility amongst the conference participants, which will significantly aid in increasing the effectiveness of your business meetings. BSNL Web Conferencing Service does not require expensive end points; all that you require are a PC, Webcam and an ADSL Connection.

It is ideally suited for users at all levels in large corporate houses, Small and medium businesses, SOHOs & quality conscious individuals to enhance collaboration, increase productivity and save costs.

a. Interactive Gaming: This service is offered in association with a franchisee Broadband customers can visit http://bsnl.indiagames.com/ and subscribe this service. Various monthly plans are available. BSNL toll free number is 1800 425 0500.
b. Multiplay (A term meaning offer of multiple services such as Voice, Data, Video, Games etc. as listed above).
c. VPN on broadband. Dial up VPN Service.
d. Virtual Private LAN Service (VPLS).
e. Bandwidth on Demand (User and or service configurable)

9.10 WiFi Enabled ADSL modem

BSNL provides WiFi enabled ADSL modem on rental basis. Customer can purchase it from the market also. This type of modem allows the customer to use broadband service through out the coverage area of WiFi modem i.e. wireless link between PC and the ADSL modem.

9.11. Important Do's and Don'ts for BSNL Broadband customers

Does:

- ✓ No phone/ fax should be connected before splitter. Change your password regularly
- ✓ Please remember/ write down your password after changing each time
- ✓ Check your usage regularly, you can see usage of current month and last twelve months
- ✓ Note that exploring, listening music, chatting, online gaming, email etc all are part of download.
- ✓ Please keep automatic updates disabled on your computer to avoid unanticipated high usage.

Don'ts

- ✓ Please do not disclose your broadband User ID and Password to anybody.

9.12. Customer Premises Installation

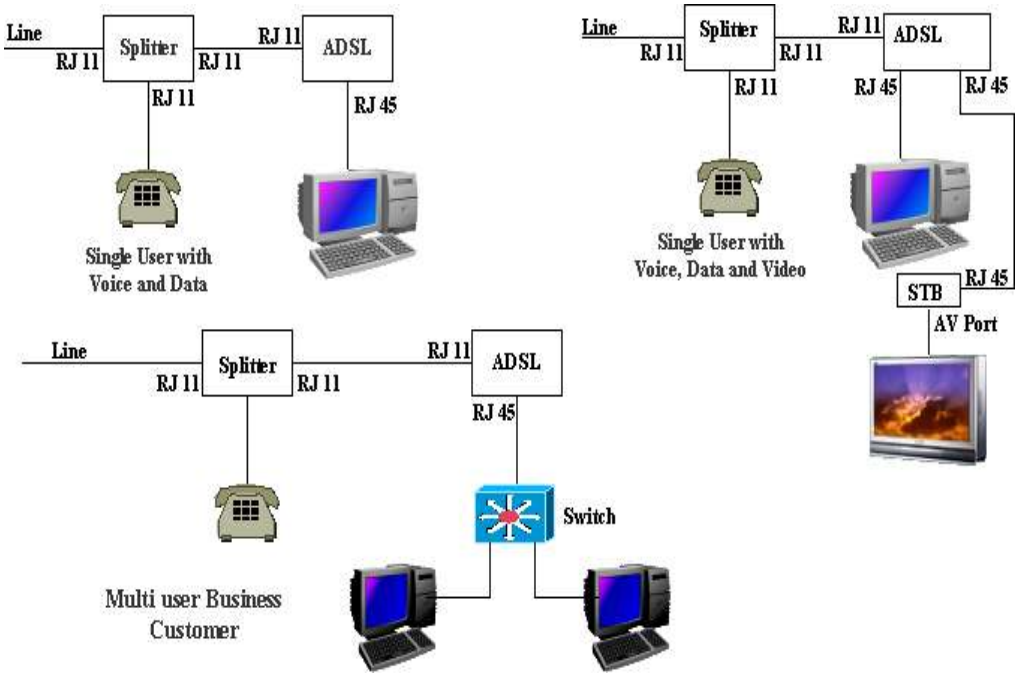


Fig 2: CPE Installation

Single User (SU): Only one PC can be connected to BSNL Broadband connection.

Multi User (MU): Customer is allowed to share one BSNL broadband connection among multiple PCs (Often a need of Cyber Cafes, Business setups)

Static IP address: For many services such as video conferencing, VPN etc. a fixed IP known as Static IP is required.

Dynamic IP: For normal internet browsing, the customer does not require static IP. In such cases, BSNL allocates temporary IP address to the customer when a session is initiated.

Speed Check: Customer are assured of promised speed. They can check it for their connection at link http://www.speedtester.bsnl.co.in/ The check is performed by measuring the speed of a file transfer. The file transfer is counted towards download limit.

Data Usage: This is aggregate of data uploaded and downloaded through broadband connection. When a customer subscribes to Games on Broadband, the data usage is normally not charged separately i.e. it becomes part of monthly rent for Games service or is on per download basis). The Data Usage is accounted in GB (Giga Bytes). One GB(Giga Bytes) is 1024 Megabytes.

9.13 CONCLUSION

Broad band is an emerging technology which is used to get the high speed internet services. The better understanding of broad band ADSL technology will facilitates the providers to handle O&M in better way.

10 BROADBAND MULTIPLAY

10.1 LEARNING OBJECTIVE

In this chapter multiplay broad band is covered. After reading this chapter, the participants will be able to understand the concepts of rural broad band, multiplay broad band, VPN, SLA, value added services, messaging services, internet data center services and other broad band services like IP multicasting services, on demand services etc.

10.2 What is BB Multiplay?

The triple play service means providing the following service to the customer: -

- Data (Internet)
- Voice (VoIP and not the PSTN which is already provided on broadbandalso)
- Video (IPTV, VoD or in general live broadcast and stored broadcasting using video streaming protocols)

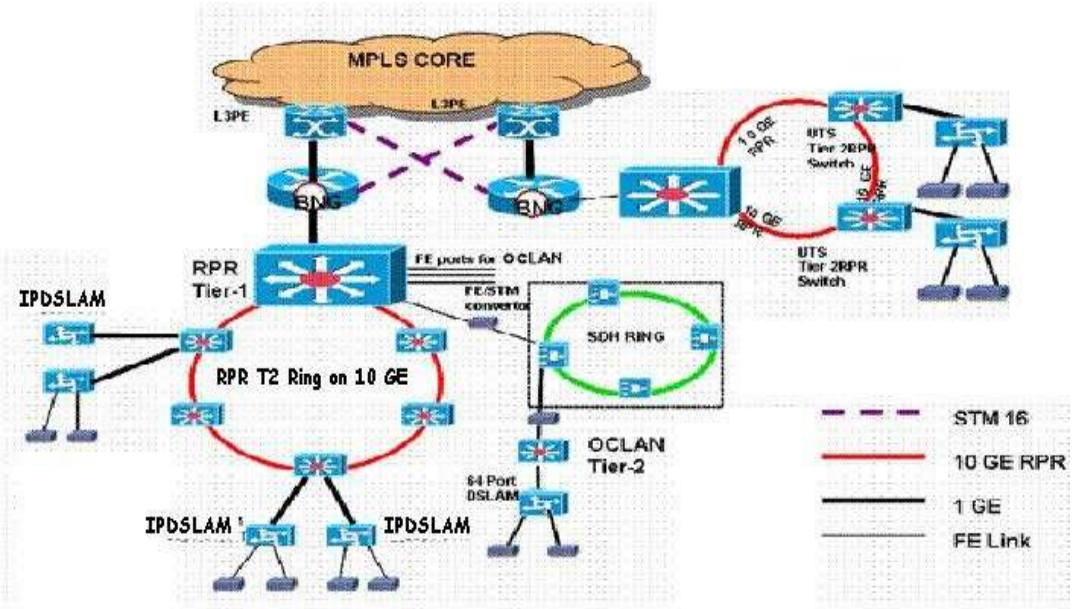


FIG 1: N/W ARCHITECTURE BROADBAND MULTIPLAY

10.3 Components of Broadband Multiplay

The BSNL's Broadband multiplay network consists of the following components:

- L3PE (MCR / PE Router of NIB-2 Project 1 – Supplied by HCL).
- BNG – Broadband Network Gateway (Connects Multiplay Network to NIB2 Backbone Project 1, through L3PE).

- RPR (Tier-1 Switch and Tier-2 switches in the ring Provides connectivity to BNG & vice versa).
- OC LAN Tier-2 Switch.
- DSLAM.
- ADSL CPE.
- DSL Tester.

DSLAM

DSL Access Multiplexor or Demultiplexor.

• Supports PPP and ATM for xDSL services.

• Supports GE and FE connectivity for uplink, cascading, and other types of data connectivity.

• Supports VLAN.

RPR

Resilient Packet Ring(RPR) Switch:

• The traffic from access devices and remote aggregation devices is aggregated in RPR and forwarded to the Core Network.

• Resilience: Proactive span protection automatically avoids failed span within 50ms.

• Ring Topology gives the scalable option of having more than 100 nodes in a ring.

• RPR has the ability to differentiate between low & high priority packets.

Broadband Network Gateway(BNG)

• It routes traffic to and from broadband remote access devices DSLAMs /OLTs on an Internet service provider's (ISP) network.

• It works as Multi Service Edge Router(MSER).

• Service specific logical mini routers are configured in BNG called context or routing instances.

• BNG maps the traffic coming from access networks elements and forward to uplink L3PE VLANs IP MPLS Network through corresponding service context.

• Authentication, Authorization and accounting processes happen via radius servers configured logically in BNG.

10.3.1 CHANGES IN BROADBAND MULTIPLAY AFTER BROADBAND

i. T1 & T2 changed from star topology to RPR ring topology – High reliability
ii. IP-DSLAM connected on GE interface as compared to FE interface.
iii. BNG behaves as customer edge router whereas BRAS was a PE Router.
iv. BRAS were present at 23 “A” locations only whereas BNG is present upto “B”type cities.

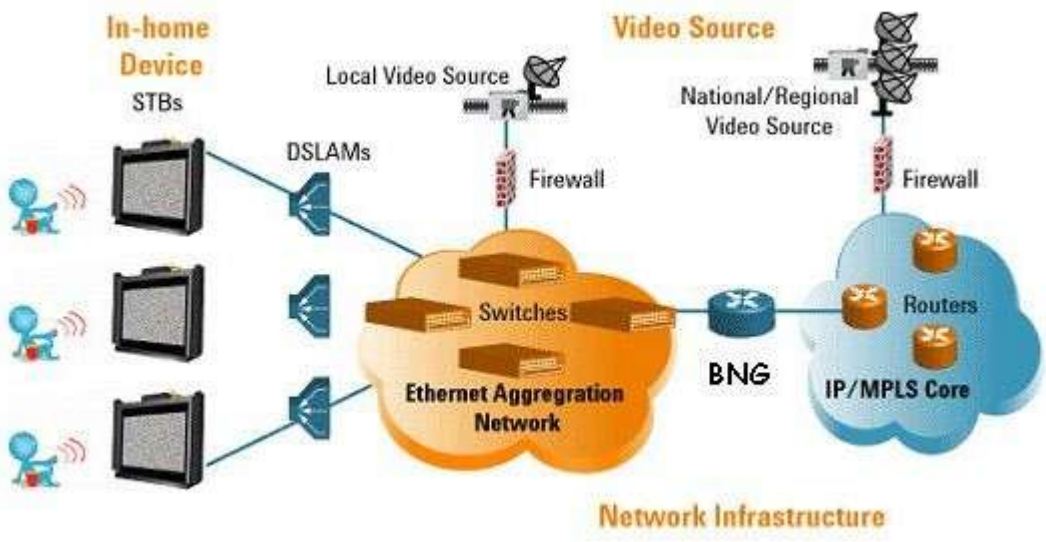


FIG 2:Network Infrastructure

SERVICES

- IPTV/ TVoIP
- Video on Demand (VoD)
- Games on Demand (GoD)

IPTV or TVoIP delivers television programming to households via broadband connection using Internet protocols. It requires a subscription and IPTV set-top box(STB), this box will connect to the home DSL line and is responsible for reassembling the packets into a video stream and then decoding the contents. IPTV is typically bundled with other services like Video on Demand (VOD), Voice Over IP (VOIP) or digital Phone, and Web access. IPTV viewers will have full control over functionality such as rewind, fast-forward, pause, and so on.

If you've ever watched a video clip on your computer, you've used an IPTV system in its broadest sense. The video stream is broken up into IP packets and dumped into the core network, which is a massive IP network that handles all sorts of other traffic (data, voice, etc.). VOD (Video on Demand) service allows the user the luxury of watchingthe movie of his / her choice at his / her convenience.

10.3.2 DIFFERENCE BETWEEN VOD ON BB & VOD ON DTH

In DTH, as it is broadcasting and not communication so the request for VOD has to be registered through some other mean than the Set top Box say can be through phone call, SMS or Internet and the same four to five movies are broadcasted and the viewers have to choose among them only and at predefined timings.

In true VOD, as offered by BSNL, the set-top box behaves just like a DVD player and viewer can select a movie from the boutique, view it at his / her desired time and day, pause it, rewind it, forward it or can have the exactly same experience has viewing from a personalized DVD player. This is only possible because of the two-way communication between the set-top box and the server. In BSNL one has a choice of selecting from

hundreds of movies while VOD offered by DTH providers may have only few movies to offer.

10.4 Set-top-Box

The set-top box is a smart solid-state device that acts as the gateway to a host of services offered on the BSNL Multiplay network. On one side the set-top box interfaces with the television using the 3-RCA or the S-Video ports, and on the other side it is connected to broadband ADSL modem via the Ethernet port. BSNL franchisee in Pune has named the set-top box as WICE Box (Window for Information, Communication and Entertainment) and supports all sorts of inputs like audio, video, tablet data, text data, pointer devices etc. it has a USB port and a microphone and headphone jack in addition to essential ports. In future, it will be possible to connect keyboard, mouse, web cams, pen-drives and other such devices for various applications that will be provided on the box. The WICE box is fully upgradeable through the network. This means, any new application launched will be directly uploaded into WICE box without getting the box to service center. All software upgrade will be handled this way.

10.5 VOIP

- The technology used to transmit voice conversations over a data network using the Internet Protocol.

A category of hardware and software that enables people to use the Internet as

- the transmission medium for telephone calls.
- VoIP works through sending voice information in digital form in packets,
- VoIP also is referred to as Internet telephony, IP telephony, or Voice over the Internet (VOI)

10.5.1 BENEFITS OF VOIP COST REDUCTION

- Toll by-pass
- WAN Cost Reduction

10.5.2 OPERATIONAL IMPROVEMENT

- Common network infrastructure
- Simplification of Routing Administration

10.5.3 BUSINESS TOOL INTEGRATION

- Voice mail, email and fax mail integration
- Web + Call
- Mobility using IP

10.6 CONCLUSION

BSNL has planned to roll out this service in 898 cities progressively. The service is

being provided at Pune, Chennai, Bangalore, Kolkata, Hydrabad and Ahmedabad. This service is being provided through franchisees. Many cities already have franchisees for broadband content and they can offer this service. A pool of private IP addresses will be allotted by BSNL to the said franchisee, which will be used for allotting IP address to the IPTV customer.

11 TELECOM REGULATION

11.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Laws and Regulations
- Regulatory Bodies:
- Regulated Activities

11.2 OVERVIEW

India is a heavily regulated telecoms market with telecoms service providers being required to obtain a license in order to provide services. Foreign investment caps have recently been removed and 100% foreign ownership is permitted.

A foreign investment approval has to be obtained for foreign investment. There are three restrictions in the broadcasting sector – (a) only 49% foreign investment is permitted in terrestrial FM; (b) only 49% foreign investment is permitted in the up-linking of news and current affairs television channels; and (c) only 26% foreign investment is permitted in the uploading/ streaming of news & current affairs through digital media.

There are also restrictions on participation of foreign nationals in the management of telecoms companies. Restrictions on virtual providers and resale of services have recently been lifted. Use of voice over IP and internet telephony is also restricted. There are regulations related to the need to ensure security in networks of telecoms providers.

11.3 LAWS AND REGULATIONS

Indian telecom law is based on the Indian Telegraph Act, 1885 which gives the Government the power to regulate the use of telegraphs in India. Based on this statute, the Government has issued regulations for various types of licenses – universal access, national long distance, international long distance, internet services, virtual network operators, etc. In addition, Indian Wireless Telegraph Act, 1933 contains certain regulation relating to wireless telegraphy

The Telecom Regulatory Authority of India (TRAI) has been set up under the Telecom Regulatory Authority of India Act, 1997. Some regulations are also issued by the TRAI including, for example, 'do not call' regulations and interconnection rules.

The Information Technology Act, 2000 has indirect application to some telecom and internet related issues, particularly surveillance rights of the Government. The Cable Television Networks (Regulation) Act, 1995 regulates cable television.

According to TRAI’s regulation on unsolicited commercial communication, telcos must verify every SMS contents with a registered template before delivering it. The process, also known as content-scrubbing, was activated on Monday at 00.00 hours after multiple delays in the past caused due to lack of readiness in the industry.

Telecom operators say the onus lies on telemarketers and individual businesses to comply with the standards if they wish their services should continue.

11.4 REGULATORY BODIES

The Department of Telecommunications (DoT) - which is a ministry of the Government of India - is the licensing authority. It sets out the regulations permitting the grant of licences to telecom service providers. It also issues notifications from time to time on telecom laws.

The TRAI is empowered to issue regulations in certain areas and provide recommendations to the DoT in other areas. It is a somewhat unique arrangement where two regulators are involved in the regulation of telecoms.

The TRAI is an independent body and not controlled by the Government, except that the Government appoints its officers. There are certain divisions of the DoT that manage specific functions such as the Wireless Planning and Co-ordination (WPC) wing which is involved in spectrum management.

11.5 REGULATED ACTIVITIES

The following are the key categories of telecom services for which licences are required:

a. Universal access licence – a jumbo licence that covers various other licences such as access services and National and International long distance service
b. Cellular mobile services
c. National long distance
d. International long distance
e. Internet services
f. Satellite mobile services
g. Infrastructure providers
h. Audiotex licence (essentially for conferencing services)
i. Other service providers (essentially for call centres)
j. Virtual network operators for most of the above licences
k. Telemarketer registration

11.5.1 Registration and Licensing

All of the regulated services require licences from the DoT. The 'Other Service Provider' category (see Regulated activities) is a registration rather than a telecom licence. The same is the case with telemarketers who have to register with the TRAI.

11.5.2 Establishment

All telecom services have to be provided by Indian incorporated entities. Such services cannot be provided by foreign domiciled entities. International bandwidth can be sold and billed to customers at the foreign end of such connectivity but selling without a licence to customers at the domestic end is likely to violate applicable law.

11.5.3 Interconnection/Roaming

Both interconnection and roaming are regulated by the TRAI. The regulations cover arrangements among service providers for the payment of interconnection usage charges throughout the territory of India. The regulations cover tariffs for all telecommunication

services and also impose a ceiling on the roaming charges that may be charged by a service provider. Further, the regulations impose a reporting requirement with regards to the tariff fixed by a service provider. The service provider is also required to report to the authority the interconnection charges and revenue sharing arrangements agreed mutually among the service providers.

11.5.4 Consumer Protection

By and large, there are no differences in regulations for services provided to businesses as opposed to services provided to retail customers. Some regulations do require that aspects of such regulations be specifically mentioned in customer contracts. As mentioned in the Interconnection/roaming section, tariff regulations do apply in respect of the tariffs that can be charged to consumers.

11.5.5 Taxes and Fees

Most telecom service providers have to pay a license fee, which is 8% of their "adjusted gross revenue". This does not include spectrum fees which are payable separately based on auctions conducted. This does not apply to Other Service Providers and Telemarketers. Goods and Services tax is generally applicable on telecom services at a rate of 18%.

11.5.6 Enforcement

The penalty for operating a telegraph without permission is a fine of up to INR 500. In the case of wireless telegraph, it is imprisonment of up to 3 years or a fine of INR 1000 or both. For breach of a license condition, the penalty is a fine of INR 1000; and a further fine of INR 500 for every week of continuation of the violation.

As these penalties are fairly low, penalties for breach of telecom licences are based more on damages mentioned in licence agreements with telecom providers. For example, a universal access or national long distance telecom operator would be liable for damages of up to INR 500 million.

Further, telecom providers are required to provide bank guarantees. On violation of licence conditions, the bank guarantees can be invoked by the DoT.

11.6 CONCLUSION

After discussing the topics like Laws and Regulations, Regulatory Bodies and its activities etc Participants will have better understanding and ease of carrying day to day work.

12 ENTERPRISE SERVICES

12.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Enterprise Voice, Mobility Service
- Enterprise Data Services
- Managed Enterprise services.

12.2 INTRODUCTION

There is a growing need of connecting various branches of an Enterprise, which might be located across the globe. Lease line & Internet bandwidth has become a must for networking multi site business. Today's business owner wants to focus more on its core competencies rather than trying to implement such things of their own. Such a networking solution often requires not just bandwidth, but hardware components, security solution and maintenance also.

12.3 KEY FEATURES

a) Complete Reliable Services from One Interface Organization.
b) Supply of not only Bandwidth but also Leased line Modems / Routers etc. i.e. Complete Telecom Solutions.
c) Secured Network.
d) Proactive Monitoring of the customers Network.
e) Guaranteed SLA.

BSNL offering verities of Enterprise solutions as discussed below:

12.4 ENTERPRISE VOICE/MOBILITY SERVICE

12.4.1 EPABX

BSNL permits telephone subscribers to use their own PABX/EPABX connected to the BSNL network under certain commercial/technical conditions:
a) The type of Subscriber owned EPABX should be approved by BSNL
b) External extensions outside subscriber's premises will be permitted only on the specific approval of the concerned authority and charged as per departmental tariff. In cases where external extensions from subscriber owned EPABX are provided within the premises of the subscribers using their own cables and wires without crossing any public road, no charge will be levied.
c) Subscriber is free to use the existing internal wiring of the internal extensions left at the premises after the closure of the EPABX.
d) External extensions from subscriber owned PABX may be provided by the department and charged. Underground cables and lines may continue to be maintained by the department since the same may be required for provision of various telecom services the subscriber may require.

e) In cases where BSNL feels that the existing cables/overhead wires are not be used/likely to be used by the company the same can be made over to the user after recovering the depreciated value of assets.
f) Where subscribers themselves provide and maintain external extensions from the EPABX, applicable license fee would be charged if the extensions are crossing a public road.
g) Cases where PBX/PABX facilities are surrendered before the expiry of the guarantee period will be regulated as per Company rules.

12.4.2 CENTREX

It is central office based communication service, which integrates all your multi located telephone lines (Existing and New) into a single highly functional communication group with more distinctive features without any additional equipment (like EPABX) at your premises. Highly cost effective, Free Intra Centrex calls, No worry to select innovative (PBXs) equipment, No risk of obsolescence of technology, No requirement of power supply, No need to waste valuable floor space, No annual maintenance charges, totally flexible are some of the salient features of Centrex facility.

The following conditions are prescribed for the provision of Centrex facility:

a) The registration amount, initial deposit, monthly rental, installation charges, etc for DELs under Centrex shall be same as normal DEL.
b) All intra Centrex calls shall be free.
c) The free monthly call shall be allowed on the DELs covered under the Centrex.
d) There is no upper limit on the number of members in the Centrex group.
e) The option of consolidated billing, payment and discount, under the **" Corporate Account Holders scheme"** where applicable, may be provided to the groups or organizations covered under the Centrex. However, the condition of combined billing for all the DELs covered therein shall be mandatory. In other words, wherever technically feasible to generate single/consolidated billing/payment the Centrex feature shall be offered, otherwise it will not be provided. However, existing Centrex groups may continue even without consolidated billing/payment.
f) The DELs belonging to public services like, call centers, enquiry numbers, ISP Dial in numbers, paging service numbers, etc., besides franchises, PCO holders shall not be part of the Centrex group.

12.4.3 TOLL FREE SERVICE

This service is an ideal business promotion tool for business communities who want their customer to call them free of cost. Totally customer oriented organizations can provide information about their products, allow customers to place orders or even register their complaints/suggestions and offer assistance to customers without the user getting charges. Other features are:

a) This service can be taken on any existing telephone line without requiring any additional line.
b) Any user of BSNL telephone network can call FPH/TLF number free of charge.
c) All charges are to pay by the FPH/TLF holder (who has taken this service & receive the call).
d) The service subscriber is allotted a FPH service number (Eleven digits). For same FPH service number, the subscriber can have many destination numbers.

e) Any subscriber who is willing to become a free phone subscriber outside the cities where the IN switches are installed, the call charges will be as per the national STD tariff.
f) The charges indicated here are FPH service charges and they do not include the normal charges levied for basic telephony service.
g) Billing for the same is separately issued to subscriber on monthly basis, which does not include landline rent & charges on which the TLF/FPH services is taken.
h) Access Code is 1800233 (For new IN platform).
i) Total digit for service is 1800-233-ABCD (For new IN platform)
j) Vanity numbers are available for selection of ABCD on charge basis.

12.4.4 ISDN

ISDN Has emerged as a powerful tool worldwide for provisioning of different services like voice, data and image transmission over the telephone line through the telephone network. ISDN is being viewed as the logical extension of the digitalization of telecommunication network and most developed countries are in different stages of implementing ISDN.

12.4.4.1 CONECTIVITY

The ISDN subscriber will have full connectivity, nationally, to other analog telephone subscribers. At present ISDN services are available to and from India for the following countries:-

Australia, Austria Belgium, Canada, Denmark, France, Germany, Ireland, Italy, Israel, Japan, Malaysia, Netherland, Norway, Phillipines, Singapore, Switzerland, Thailand, U.A.E, U.S.A

12.4.4.2 SERVICES OFFERED BY ISDN.

a) Normal Telephone & Fax (G3)
b) Digital Telephone -with a facility to identify the calling subscriber number and other facilities.
c) G4 Fax
d) Data Transmission at 64 Kbps with ISDN controller card
e) Video Conferencing at 128 Kbps
f) Video Conferencing at 384 Kbps (Possible with 3 ISDN lines)
g) ATM (Asynchronous Transfer Mode) or PVC (Permanent Virtual Circuit)

12.4.4.3 SUPPLEMENTARY SERVICES SUPPORTED BY ISDN.

a) Calling Line Identification Presentation(CLIP)
b) Calling Line Identification Restriction(CLIR)
c) Multiple Subscriber Number(MSN)
d) Terminal Portability(TP)
e) Call Hold(CH)
f) Call Waiting(CW)
g) User to User Signaling (UUSI)

12.4.4.4 Types of Accesses

There are two types of "accesses" (connections) for ISDN.

12.4.4.5 Basic Rate Access (BRA): 2B+D

a) 2 Channels of 64 Kbps for Speech And Data.
b) 1 Channel of 16 Kbps for Signalling

12.4.4.6 Primary Rate Access (PRA): 30 B+D

a) 30 Channels of 64 Kbps for speech and data.
b) 1 Channel of 64 Kbps for signalling.

12.4.4.7 3G MOBILE SERVICE

BSNL 3G voice service also come under the category of Enterprise Voice service

12.5 ENTERPRISE DATA SERVICES

12.5.1 MPLS Based VPN Services

Keeping pace with the technological trend to provide latest and varied value added services to its customers, BSNL harnesses IP Infrastructure based on MPLS Technology to offer world class IP VPN services. MPLS is an acronym for "Multi Protocol Label Switching".

MPLS VPN is a technology that allows a Service Provider like BSNL to have complete control over parameters that are critical to offering its customers service guarantees with regard to bandwidth throughputs, latencies and availability. The technology enables secure Virtual Private Networks (VPN) to be built and allows scalability that will make it possible for BSNL to offer assured growth to its customers without having to make significant investments. BSNL would now be geared to provide Bandwidth on demand, Video Conferencing, Voice Over IP (VoIP) and a host of other value added services that could revolutionize the way a corporate business works!

MPLS based VPNs reduce customer networking complexity, costs and totally do away with the requirement of in-house technical work force. Rather than setting up and managing individual point-to-point circuits between each office using pair of Leased Lines, MPLS VPN customers need to provide only one connection from their office router to a service provider edge router.

BSNL has tied up with various Networking solution providers to provide end-to-end solution to its valued customers, including Customer End (CE) routers and other networking components.

12.5.1.1 What advantages does MPLS VPN have over other Technologies:

BSNL's primary objectives in setting up the BGP/MPLS VPN network are:

a) Provide a diversified range of services (Layer 2, Layer 3 and Dial up VPNs) to meet the requirements of the entire spectrum of customers from Small and Medium to Large business enterprises and financial institutions.

b) Make the service very simple for customers to use even if they lack experience in IP routing.
c) Make the service very scalable and flexible to facilitate large-scale deployment.
d) Provide a reliable and amenable service, offering SLA to customers
e) Capable of meeting a wide range of customer requirements, including security, quality of Service (QOS) and any-to-any connectivity.
f) Capable of offering fully managed services to customers.
g) Allow BSNL to introduce additional services such as bandwidth on demand etc over the same network.

12.5.2 INTERNET LEASED LINE

a) ILL is an always on Internet connection based on leased line access (i.e. dedicated access). Leased lines provide the last mile access from the user premises to BSNL equipment.

b) Required by heavy users like educational institutes, big cyber café, small and medium corporate house who need to constantly remain online with Internet.

c) Permanent Internet connection as compared to the temporary connectivity through dialup access.

d) Far superior quality as compared to dialup, thanks to digital signaling, less noise, fewer exchanges etc.

e) A scalable access method - Bandwidths starting from 64 Kbps to 2 Mbps to 8 Mbps, 10/100Mbps Ethernet connectivity, 34/45/155 Mbps and beyond can be deployed.

f) Since the access is "always on", it is possible to associate a pool of permanent IP addresses with a particular leased line. Using IP addresses provided by BSNL, it becomes possible to deploy a variety of services such as mail, FTP, WWW, DNS, and proxy, to name the most common requirements of organizations. In other words, leased lines enable hosting of services of all types, and provide a platform for enterprise intranets and extranets, apart from what we may term as "entry level" services such as messaging, which still account for over 70 percent of all Internet access.

g) Leased Internet bandwidths up to 2Mbps are provided using modems on copper pair, however, large bandwidths are provided using OFC in the last mile.

12.5.3 VPN OVER BROADBAND

Presently , BSNL is providing VPNoBB for General EB customers as well as e-Governance projects for bandwidth 256 kbps to 24 Mbps.

12.5.3.1 V-SAT Network

The network consists of a Hub located at Bangalore and VSATs located throughout the country. The VSAT communicates to the HUB through Express AM1 Satellite. All VSATs are connected in STAR topology and VSAT to VSAT communication is through the HUB at Bangalore. For more information on the service kindly read the FAQ . Ku band VSAT network of BSNL is capable of providing high speed data transfer up to 2Mbps (presently 512 Kbps) and voice communication service covering the entire country.

TARIFF

a) BSNL offers competitive and affordable Tariff.
b) The Tariff is offered based on customer applications.

6. CUSTOMER CARE

a)Reliability of Network 99% and above.
b) 24x7 Help Desk and Technical support.
c) Zone wise customer support centers for quick Fault clearance.
d) Billing information can be accessed through Web Self care.
e) Complaints can be booked either through internet, Toll free Phone Number.

12.5.4 LEASED LINE

To transmit data between computer and electronic information devices, BSNL provides data communication services to its subscribers. It offers a choice of high, medium and low speed leased data circuits as well as dial-up lines. Bandwidth is available on demand in most of the cities. Managed leased Line Network (MLLN) offers flexibility of providing circuits with speeds of n x 64 Kbps up to 2 Mbps. Useful for internet leased lines and international principle Leased Lines (IPLCs).

For dedicated point to point speech, private wire, tele-printer and data circuits are given on lease basis. Leased circuits are provided to subscribers for internal communication between their offices/factories at various sites within a city/town or different cities/town on point to point basis, or on a network basis interconnecting the various sites.

12.5.4.1 Managed Leased Line Service(MLLN)

The MLLN is a Managed Leased Line Network system which is proposed to provide Leased line connectivity. The State-of-the-art technology equipment MLLN is designed mainly for having effective control, monitor on the leased line so that the down time is very much minimised.

SERVICES

Speech Circuits (Hot Line or Private Wire)

Local or Long distance circuits within two locations in a city or between two different cities provided for the same applicant. The Terminating equipment at both ends is telephone without dialing facility. Both way signaling and speech is possible.

Data Circuits

Local or Long distance data circuits at different speeds viz. nx64 kbps and 2 mbps. Data Circuits are of different types:

a) Point to Point Data Circuits - Local and Long Distance

b) Private Data Network - More than one Local or Long Distance leased circuits converging on a location such that data from one leased circuit can be transferred automatically to another leased circuit for the same subscriber.

c) Closed User Group - Leased circuits can be used by more than one legal entity if they form closed user group. The following categories of user groups constitute closed user groups for the purpose of licensing Private Telecom Networks.

12.5.5 IDC SERVICE

BSNL IDC is a service brand name for the data center services provided by Bharat Sanchar Nigam Limited, A leading telecom service provider in India. BSNL IDC is a state-of-the-art data center located at six major locations across India who maintains most fault tolerant networks. Internet Data Center services comprises IT operations which is provided with the expertise well recognized worldwide.

12.5.5.1 Managed Co-location Services

Co-location refers to co-locating your server or hardware at a Service Provider's Data Center and willing to pay only the rental charges for Bandwidth, racks space and climate control.

12.5.5.1.1 Features

a) Customers have flexibility to even choose the SLAs most suited to their business environment
   - Tier III uptime certified Datacentres, 99.982% uptime guaranteed SLA
   - Custom-designed racks and space
   - Scalability on Demand anytime

b) High levels of security (ISO 27001 & SAS 70 Certified Datacentres)
c) 24x7 physical security – Security guards, CCTV surveillance and biometric access control
d) Flexible pricing customized to customer's convenience.

12.5.5.2 Managed Hosting Services

It is a type of hosting in which the Customer leases an entire/ or part of server dedicated/ or shared with anyone. This is more efficient, client oriented and flexible. Here Customers are having full control over the servers and has choice of operating system, system configuration etc. Customers have to pay according to their requirement about system configurations. It can provide less overhead and a larger Return on Investment (ROI).

12.5.5.2.1 Features

a) Convenience: Stop worrying about the fundamental problems of buying and maintaining hardware, giving you the convenience of focusing on your business instead diverting your mind towards management of infrastructure management.
b) Control: Have control over the configuration, administration of your servers, choice of hardware etc.
c) Scalability: Customer can increase resources such as memory or storage etc.
d) Security: To protect your data security parameters can be tailored to Customer requirements. Customer can adopt multiple levels of security measures to safe and smooth operations.
e) Faster deployment of services
f) Vanishes threat of obsolescence

g) Rapid response (e.g. in matters of configuration etc.)

12.5.5.3 Managed IT Services

It is a way of shifting day to day responsibilities of managing IT infrastructure in an efficient and more effective manner.

12.5.5.3.1 Features

a) Clients can use our expertise in managing servers, storage, security, database, backup and DR, capacity planning, facilities management, service desk operations and remote infrastructure management.
b) Any type of enrolment can be in an open and transparent way with a dedicated account manager providing a single point of contact and a personal commitment to successful outcomes.
c) Our skill set covers network engineering, business information systems combined with broad IT project management capabilities to ensure that your technology and business goals are achieved.

12.5.6 ENTERPRISE BROADBAND

12.5.6.1 Wi-Fi

Wi-Fi Services have been introduced for providing high speed internet access at convenient public locations here under called as Hot Spots. Installation of Hot Spots is already under process at various cities / locations.

Hot Spot Type-A is applicable for public utility services like Airports, Railway Stations, Universities and their campus etc initially for a period of 90 days from the date of its launch.

Hot Spot Type-B is applicable for personal type of services like Hotels, private owned institutes/ Colleges/ libraries/ Universities and their campuses etc. Prepaid schemes for Hot Spot B owners on commission basis is also available.

12.5.6.2 DSL BROADBAND

DSL is a wireline transmission technology that transmits data faster over traditional copper telephone lines already installed to homes and businesses. **DSL**-based **broadband** provides transmission speeds ranging from several hundred Kbps to millions of bits per second

12.5.6.3 FTTH BROADBAND

Fiber to the home (**FTTH**) is the delivery of a communications signal over optical fiber from the operator's switching equipment all the way to a home or business, thereby replacing existing copper infrastructure such as telephone wires and coaxial cable.

12.5.6.4 VPN OVER FTTH

The VPNoFTTH service for e-governance projects will be offered as on 'Add On' service on BSNL FTTH only to those customers who opt a BB plan of minimum Rs.700/- per month values. The customers will be able to access either VPN or Internet at a time.

12.6 MANAGED ENTERPRISE SERVICES

12.6.1 Manage Network Service

BSNL Managed Network Services is a fully managed Secured Data services, providing a truly one-stop and a complete experience that significantly reduces risks and complexities involved in implementing and maintaining a robust IP network. It brings together all of a business' communications needs in an integrated offering.

With the promise of an integrated platform with one-stop convenience and fully managed experience, BSNL Managed Network Services is an All-in-One comprehensive bundle of hardware, connectivity packages and managed services.

It is a solution that simply, affordably and reliably supports your business.

Comprehensive Service Package:

The "One-Stop" promise delivered by BSNL Managed Network Services is beyond technical integration of the best-in-breed network and hardware setup. It offers truly executable technical and business propositions for your business today:

a) No CAPEX
b) No risk of technical obsolescence
c) Scalable according to changing business needs
d) One helpdesk number to call for troubleshooting and fault resolution.
e) Integrated customer report (Web Based) giving you a complete view of your network

12.6.2 Managed Global Audio Conferencing Service

BSNL has launched Global Audio conferencing Service in association with British Telecom (BT). It is an easy to use, reservation-less conferencing service aimed at Enterprise customers. The Enterprise customer has to subscribe the service by filling a form as application. There are no charges for service subscription. Charges are only for the usage of the service.

12.6.3 Managed SaaS

BSNL Managed SaaS (Software as a Service) Business Mail Service has been launched with M/s Microsoft India Ltd.

12.7 OTHER ENTERPRISE SERVICES

12.7.1 Web Colocation

Web Co-location is an easy and cost effective solution to house a company's powerful infrastructure without losing the administrative control on the equipments.

12.7.1.1 TypicalApplications

E-commerce, financial, B2B, email and other data storage and retrieval.

12.7.1.2 Facilities

a) Air-Conditioned, dust free, fire-safe and secure space with racks (42 U) at the nodes for co-location.
b) Necessary CAT5 cabling for connecting the server to the LAN.

c) AC and DC power supply.
d) One Sancharnet account of 100 hours to customer to enable administration of the server.
e) BSNL provides one IP Address per site on request

12.7.2 Fleet Tracking

An innovative on-line tracking system powered by BSNL to manage fleets comprising of trucks, car carriers, trailers, tankers, containers or vehicles moving hazardous and specialty explosive chemicals etc.
The eTracK vehicle tracking system uses vehicle-mounted, microprocessor-controlled device which sends periodic messages from the vehicle to a network command centre through SMS/GPRS. The received data is authenticated and forwarded to an application server which provides tracking information through an internet. Customers are provided a user name and password to access the fleet information on line. The user also has options to receive tracking information via e-mail, fax or SMS besides the facility of calling the customer support team on a toll-free telephone line.

12.7.2.1 Features

a) No driver intervention
b) Automatic Real time system.
c) Vehicle information available 24 X 7
d) Secured internet access anywhere in the world.
e) Information through fax and emails
f) Mobile Query SMS
g) Widest Coverage on National highways through 20000+ BSNL towers spanning across 5000+ cities/town
h) Transparency and Trust at your doorstep with MIS reports for better fleet management

12.7.3 Video Conferencing

'v-Sangoshti' BSNL Managed Public Room video Collaboration Service, is a unique service, making video conferencing facility accessible and simple to everybody across nation. Its ready to use infrastructure , along with rapid connectivity, ease of use and lower total cost of ownership. v-Sangoshti studios are 24x7 available video collaboration rooms that are connected to multiple such public rooms nationally and can be used by any Retail, SMB, Enterprise or any PSU/Government customers through reservation on demand basis on "pay as you go" model. These studios have the capability to connect to any private video enabled device across Public IP, MPLS, ISDN access having SLA with ease of use, higher up-time, proactive operator assistance and high definition video resolution to the users. It provides additional facilities of recording, live streaming, web casting and can connect to audio devices i.e landline/mobile on user demand.

12.7.4 Web Hosting

Web hosting is a service that allows users to post Web pages to the Internet. It allows users to publish their own information resources to any Internet user interested in accessing them. It is a business that provides the technologies and services needed for web sites to be viewed on the web.

12.7.4.1 Features

a) Domain name hosting
b) Web Publishing : HTML pages with Browser supported MIME pages
c) Server side scripting: Perl. Java Servlets , JSP
d) Web Server: Apache, Tomcat.
e) Data base : MYSQL
f) SMTP (Exim) and POP3 (apop3d) service for each domain
g) Multiple e-mail ids per domain with flexible mail quota possible
h) FTP access for uploading /downloading files
i) Centralized authentication for SMTP, POP3,FTP and for administration
j) Multiple Web Hosting Plans to choose
k) Multi user Admin- Administration Console for the management of services & usage reports.
l) Multi User – User Administration Console for limited management of services and usage reports
   Data Transfer quota Exceeded Message Display.
m) No hard limit on quota
n) Round the clock Technical report support through Help Desk (1957)

12.7.5 Bulk Push SMS

BSNL Bulk SMS service provides a simple and user-friendly way for sending bulk as well as individual messages at affordable rates. This Service includes the facility to send both transactional and promotional SMSs. Transactional and Promotional SMS can be send by customers through our webportal/API. Promotional SMS can be availed by the Customers having telemarketing registration .

12.7.6 GSPS(Global Satellite Phone Service)

BSNL's GSPS also called satellite phone service, provides voice communication and messaging from any part of the globe. However, presently, the services will be available within India only. It is a ubiquitous service, hence can be used from all part of the country including territorial water. It is being provided through world's most advanced satellite communications network working on Inmarsat I-4 F2 satellite located at 63.90 degree East

It is suitable for persons working in remote areas or disaster affected areas – defence, border security organizations, disaster management bodies, trekkers, fishermen, maritime applications.

12.8 CONCLUSION

In this session we learn about the different Enterprise Services (Voice, Data, Broadband etc) with their key features.

13 NEW BUSINESS

13.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Software as a Service (SaaS)
- Monetization
- Infrastructure Sharing
- Virtual Network Operator (VNO)
- Satellite Business

13.2 INTRODUCTION

Now a day, telecom business has been facing tremendous challenge to meet customers demand. In this competitive market, every telecom operator is trying to provide different services to customer in cheaper price. As there are so many operators in market, ARPU for BSNL has been decreased as compared to previous time. Hence BSNL is searching new businesses to increase revenues. Few sources of additional revenue are as follows.

a) SaaS Provider.
b) Monetization of Co-location facilities.
c) Infrastructure Sharing and Renting out.
d) Smart city solution.
e) Virtual network Operator.
f) Satellite Business.
g) M2M & IOT business.

13.2 SaaS PROVIDER

BSNL is one of the top Telecom Service Provider Company in India, which is currently operating its 2G & 3G Cellular Mobile services across the Nation except in Delhi & Mumbai and has a subscriber base of more than 98 million. BSNL has installed Quality Telecom Network in the country & is now focusing on improvement & expansion of the network, introduction of the new telecom services with ICT applications in villages & winning customer's confidence.

BSNL is the only service provider, making focused efforts & planned initiatives to bridge the rural-urban digital divide in ICT sector. In fact there is no telecom operator in the country to beat its reach with its wide network giving services in every nook & corner of the country & operates across India except New Delhi & Mumbai.

Software as a service (SaaS) is a way of delivering applications over the internet – as a service. Instead of installing and maintaining software, an organisation can simply access it via the internet, freeing itself from the complex software and hardware management. SaaS application run on a SaaS providers server and the provider manages access to the application including security, availability and performance.

In wake of the Government thrust on Digital India, e- governance and other initiatives focusing primarily on technology based services for improving governance and citizen services, BSNL envisage huge potential in field of SaaS and is in a position to

undertake and execute wide spectrum such projects which are being envisaged under these initiatives.

13.2.1 SaaS Revenue share Policy

Revenue sharing is the basic feature of SaaS working. All the agreements between BSNL and SaaSPs (SaaS Provider) will be on Non-exclusive basis and the revenue sharing will be 40:60 basis irrespective of SaaS offering. Pricing model, discounts etc for the offered solution shall be detailed in the agreement which will be signed between BSNL and the SaaSP.

13.2.2 Responsibility of Software as a Service Provider (SaaSP)

The SaaSP shall be responsible for complete implementation of software solution during the period of agreement with customer including comprehensive AMC (including warranty etc.) wherever required by the customer. Complete implementation means full responsibility to implement Software solution for customer as specified by them. Further comprehensive AMC means full responsibility to undertake effective & efficient Operation & Maintenance activities as specified. This includes all incidentals/ services/ materials/ manpower/ permissions/ liaison/ licenses/ spares/ consumables etc., whether explicitly listed or implicitly required for the satisfactory completion and performance of the System as per the specifications, meeting international codes and standards. SaaSP should be capable of performing all (except providing telecom Connectivity) activities involved in end to end delivery of software value chain, including, but not limited to following: SaaSP shall have to install servers/platforms including hardware/ other software/database etc in a location finalized as per the requirements of customers.

13.2.3 Responsibility of BSNL

a) BSNL will do interaction with customer individually or jointly with SaaSP.
b) BSNL will provide telecom connectivity to SaaSP for integrating software solution as per requirement of customer. Types of connectivity are SMPP connectivity for SMSC, PRI connectivity for voice response system & WAP connectivity, Broadband connectivity for Internet, Subscriber Identity Module (SIM) etc.
c) BSNL will provide Short codes, Long Codes & Access Point Name (APN)s for SMS, USSD, IVR etc.
d) BSNL may use its man-power for deployment, field support for day to day operation & Maintenance (O&M), if required and feasible.
e) BSNL will provide support for Telecom network related problems or its services.
f) BSNL shall ensure complete compliance of all licensing and Regulatory guidelines related to its network during the whole agreement period.
g) BSNL shall make effort that Revenue is realized from the customer in the time bound manner so that SaaSP is not undue delay in payment after he has completed the obligation under the contract.
h) BSNL can provide LL/BB connectivity to end user/Customer to access SaaS hosted application. However, in such cases, the SaaSP will not have any share in the revenue. The above broad roles & responsibilities are only indicative/ tentative and may differ on case to case basis at the time of discussions with the SaaSP based on type of solution proposed and responsibility matrix finalized.

13.3 MONETIZATION OF CO-LOCATION FACILITIES

Digital India Mission of Govt. of India and Smart City Projects being rolled out by State Govt. have propelled the demand of data centers growth and as a result, the digital ecosystem in India is booming today. With the advent of digital technologies, business enterprises across India large to small are undertaking rapid digitization and are extensively using cloud-based solutions. Data consumption in smaller cities is increasing exponentially due to mass popularity of content driving organizations like Netflix, Amazon, Hotstar, Facebook, Google etc.

In view of emerging scenario, BSNL intends to monetize its spare infrastructure and space available in its Technical/ Exchange buildings in smaller cities across the country by promoting co-location services due to increased business opportunities in digital ecosystem. The Co-location is a practice of renting space for the third party (Data Center Service Provider - DCSP) servers and other computing hardware at any premise or data center facility.

The following few important services will be offered by partner through Co-location facilities.

a) Managed Storage
b) Cloud Hosting
c) Dedicated server hosting
d) Content Delivery Server etc.

This policy is aimed at facilitating the entities interested in starting a Data Center or provides Co-location Services, by providing ready infrastructure with power connection and ready bandwidth.

13.3.1 Revenue Share arrangement between BSNL and Partner

In case the partner is using the premises for cloud services in the Data Center, then BSNL can provide free cloud bandwidth for such business while all other fixed charges will remain same. However, in lieu of bandwidth BSNL will share the 20% of billed revenue for all the business in 1 year of agreement and 25% of billed revenue for all the business subsequent years (other than business continued from 1 year with 20% revenue share).

In case partner wants billing to be done by BSNL, the revenues share will be 25% in 1 year and 35% in subsequent years. The revenue share of revenue billed by BSNL will be net of License Fee.

The revenue share shall yield more than the bandwidth charges (of 3 years) provided for cloud services. Any shortfall in such revenues share can be made up in 4h and 5 year.

13.3.2 Responsibilities of the Business Partner

a) Various security guidelines issued time to time by BSNL and Govt. of India shall be complied.
b) Power backup system to be installed and maintained by the partner / BSNL based on feasibility.
c) Building security should be 24x7x365 via exclusive entrance/authorized pass system.
d) The annual charges for leasing out the infrastructure (space etc) will be payable from the 15" day of signing of the Agreement.
e) Any internal renovation of the allotted space will be the responsibility of the partner.

f) Separate electrical Sub-Meter will be installed to monitor the power consumption if required. Power charges will be however payable as per applicable FEC (Fixed Energy Charge) rate for the site. The AC charges will be in additional, if BSNL provided the AC.
g) Security Measures like Firewall etc as well as Access to the System shall be arranged and managed by the Partner.
h) It is mandatory to take Bandwidth (Primary) from BSNL.
i) Only activities related to running of Data Center/ Cloud Services/ Managed Services/Co-Location Data servers, will be carried from BSNL premises.
j) Ensure that no other activity is carried out.

13.3.3 Responsibility of BSNL

a) BSNL shall provide space (air conditioned where ever possible) including that for UPS, Power plant etc and electrical main power supply to the colocation partner. The space and power& AC as required shall be provided by BSNL on chargeable basis subject to technical feasibility and availability. In case AC is provided by BSNL and is used for cooling of BSNL area in the same building or premises also then based on the area rented out to Co-Lo Partner will be the basis for calculation of electricity charges of AC which will be fixed up by a committee of BSNL and partner representative, at the time of agreement.
b) It shall be mandatory to have Primary Connectivity from BSNL. The connectivity can be provided to the servers as per the discounting policy of BSNL. This shall be charged to the partner on annual basis in advance.
c) Primary Connectivity is an internet link provided by BSNL from its MUX to the respective Internet Data Center/ Distributed or Edge data Centre as backhaul bandwidth. However, DCSP or Prospective Customer may take another link as secondary connectivity from any other TSP for redundancy purpose. The secondary link bandwidth cannot be more than primary bandwidth.
d) The partner will be allowed to keep the allotted space under lock and key and their authorized representatives only will be allowed entry therein.

13.4 INFRASTRUCTURE SHARING AND RENTING OUT

a) Telecom infrastructure like Mobile Tower, core network etc are shared with other company to generate revenue from there.

b) Vacant building spaces offered on rent in premises situated at prime locations all over India. The spaces are ideally suited for Banks, Institutions and Autonomous Bodies etc. Land & Building portal developed & maintained by BSNL facilitates DOT and its PSU Organizations to upload the details about the vacant space proposed to be rented them.

13.5 SMART CITY SOLUTIONS

Bharat Sanchar Nigam Ltd (BSNL), a wholly owned Public Sector Enterprise of the Govt of India is a leading Telecom Service Provider in the country with PAN Delhi and Mumbai Metro Cities.

Government of India has come up with Smart City Mission where many cities have been selected for transformation into Smart Cities and in future many more cities will be

coming in the umbrella of Smart City. Essential Component in the Smart City Transformation is the implementation of new Smart ICT Solutions or implementation of Smart Solutions over existing infrastructure.

The most important requirement for Smart City implementation is Core Communication Network/Infrastructure to interconnect various Smart Elements. Considering this fact, great role of BSNL in this Smart City Mission is envisaged. As per current trends, Complete End to end Smart Solutions Implementation, which includes the Bandwidth Provisioning as well as other IT Hardware/Software/Sensors/Smart Elements/Command and Control Centre etc., is demanded.

The business aim of BSNL is to utilize the existing telecom infrastructure of BSNL for creation of Smart City Infrastructure. The foremost requirement from SP will be to design Smart ICT Solutions utilizing the BSNL existing infrastructure to the fullest.

13.5.1 List of Smart City Works/ICT based works

a) Smart Lighting
b) Smart Poles
c) CCTV Surveillance
d) Smart Parking
e) Smart Kiosks
f) Smart Transport Management System
g) Smart Building Management System
h) Citizen Centric Applications/GIS
i) Command and Control Centre
j) Smart Utility Management System (Smart water, Smart electricity)
k) Wi Fi Hot spot 12. Web Hosting and related cloud computing services
l) ICT based Solid waste Management
m) Tele-Education
n) Tele–Medicine 16
o) Public information & grievance redressal system.
p) OFC network readiness as per work requirement including supply of OF cable and ducts.

13.6 VIRTUAL NETWORK OPERATOR (VNO)

a) Bharat Sanchar Nigam Limited (BSNL), BSNL is a government owned leading telecommunications service provider in India. It provides services for retail customers and offers business solutions for corporate customers, including voice, data and other value-added telecommunications services both on wireline and wireless medium.
b) BSNL is the only “Complete Telecom Service Provider" in India having the largest network across India and providing all services across fixed, mobile, broadband, next generation IP services for both consumer and enterprise segments with its ubiquitous spread of networks across India.
c) A Virtual Network Operator (VNO) is an entity which has been granted license by Department of Telecommunications (DoT).
d) A virtual network operator (VNO) does not own spectrum/ core network infrastructure but provides telecom services by purchasing capacity from NSO (Network Service Operator) or TSP (Telecom Service Provider) using his/her access network.

e) VNOs are treated as an extension of NSOs (Network Service Operator) or TSPs (Telecom Service Provider) and are not allowed to install equipment interconnecting with network of other NSO.
f) VNOs can connect with the NSO/TSP and deliver services to their own (VNOs) set of subscribers. This means the delivery of services can be provided by the VNO while the network may be owned by the NSO/TSP.
g) BSNL intends to partner with VNO to provide voice, SMS and data to eligible Virtual Network Operators (VNOs) who is allotted license by DoT and intend to enter into agreement with BSNL on non-exclusive basis for offering such Service.

13.6.1 Responsibilities of BSNL for VNO (Mobile VNO)

a) Mobile originated calls generated by the VNO's Customer from a Service Area in home and intra circle roaming network to other destinations.

b) Mobile originated SMS generated by the VNO's Customer from a Service Area in home and intra circle roaming network to other destinations.

c) Mobile data traffic (2G/2.5G/3G/3.5G/4G/LTE) generated by the VNO's Customer from a service area to a packet data network either via a GGSN of BSNL or, up on BSNL's decision, via a GGSN/PGW of the VNO.

d) BSNL shall provide required connectivity from the concerned network elements of BSNL to VNO on cost basis. BSNL shall provide standard interfaces and any cost for integration/ adaption for these interfaces shall be borne by VNO.

e) BSNL shall provide VNO end-to-end delivery of mobile terminated calls from a national or international network to the Service area (VNO) where the VNO's Customer is located.

f) BSNL shall provide VNO end-to-end delivery of mobile terminated SMS messages from a national or international network to the VNO where the VNO's Customer is located.

g) BSNL shall provide VNO the Roaming Interconnection services through its existing agreements for National & international roaming.

h) BSNL shall provide VNO end-to-end delivery of mobile originated roaming calls generated by the VNO's Roaming Customer from a roaming network (VPMN) to other destinations.

i) BSNL shall provide VNO end-to-end delivery of mobile originated roaming SMS messages generated by the VNO's Roaming Customer from a roaming network (VPMN) to other destinations.

j) Mobile data traffic (2g/3g/4g) generated by the VNO's Roaming Customer from a roaming network (VPMN)

13.6.2 Responsibilities of BSNL for VNO (Landline)

a) Landline originated calls generated by the VNO's Customer from a Service Area in home and intra circle network to other destinations.

b) Landline data traffic generated by the VNO's Customer from a service area to a packet data network either via a data network of BSNL or, up on BSNL's decision, via a data network of the VNO.

c) BSNL shall provide required connectivity from the concerned network elements of BSNL to VNO on cost basis.

d) BSNL shall provide VNO end-to-end delivery of Landline terminated calls from a national or international network to the Service area (VNO) where the VNO's Customer is located.

13.6.3 Responsibilities of BSNL for VNO (Broadband)

a) BSNL shall Own and Manage the ISP Network including FTTH, Copper (as an Infrastructure provider), through which VNO will connect the Retail, SME and Enterprise subscribers and offer its broadband services under its own brand/name (as Virtual Network Operator).

b) VNO shall connect the subscribers to the BSNL's ISP network by laying cable, at its own costs.

c) BSNL shall provide required connectivity from the concerned network elements of BSNL to VNO on cost basis.

d) VNO shall provide customer premises equipment to provide services to Subscribers, at its own cost.

13.6.4 Roles and Responsibilities of VNO (For Mobile/ landline/Broadband VNOs)

a) The eligible companies are also required to do all the end to end management of the customer marketing, selling and servicing activities.

b) VNO may be fully equipped with all the technical infrastructure, telecom grade platform and all relevant NSS and BSS applications required to function as a telecom operator under VNO License.

c) VNO may be responsible for its Branded SIM Card, Vouchers Production and Distribution to its Supply chain (only for Mobile VNO).

d) VNO shall be fully responsible for the CAF process and compliance obligations.

e) VNO may be fully equipped with its own billing platform for purposes of retailing its Product, services; billing to its customers. VNO is responsible for billing and collection from its end subscribers.

f) VNO shall have its own usage records, Tools & systems to service all the legal requests (for e.g. Lawful Interception) of Regulatory as laid down from time to time by DoT. VNO will liaison with relevant agencies to fulfill their data requirements, and install the necessary applications to liaison with appropriate LEA to fulfill such requests.

g) VNO may be fully equipped with its own CRM, Supply chain Management, Voucher Management, channels for servicing the subscribers up to the Quality Of Service obligations.

h) VNO may have its own Mobile Number Portability (MNP) Application to service its customers and integrate to the MNP gateway via BSNL approved interfaces.

i) VNO shall have its own usage records, Tools & systems to service all the legal requests of Regulatory as laid down from time to time by DoT.

j) VNO shall provide BSNL with mutually agreed information relevant for compliance to regulations and agreements xi. VNO shall be fully responsible for all customer care and customer feedback for the services rendered

k) VNO shall be responsible for distribution, provisioning, retail price setting, sales and credit check, Revenue assurance, with relevant applicable laws or other obligations provided by relevant authorities.

l) VNO shall hold responsibility of identifying & taking corrective action on any kind of fraudulent use of its Subscribers without undue delay for reasons of minimizing commercial losses and/or any adverse effects for BSNL.

m) VNO shall be singly responsible for managing all the customer information and storing the data.

n) VNO shall provide BSNL with all relevant information on faults or planned maintenance notices which are deemed to impact BSNL.

13.7 SATELLITE BUSINESS

a) Bharat Sanchar Nigam Limited (BSNL), a Public Sector Enterprise of Government of India, is one Telecom Service Provider in India having a countrywide presence with over 100 million customers and offer hosts of other services like Wire-line voice, GSM 2G/3G, CDMA, Wi-MAX Data communication, National long distance, International Long Distance, Internet, Broad band, VSAT Services, Leased Line, etc. It is also the largest ISP offering broadband services on ADSL 2+ and FTTH to its customers.

b) BSNL is currently operating across the Nation except in Delhi and Mumbai. 2. BSNL has deployed Satellite Gateway in India and provides Global Satellite Phone Services (GSPS) using Inmarsat Satellite. Now BSNL wish to provide additional satellite based services through the GSPS Gateway such as M2M communications, communication in Vessels in sea etc.

13.7.1 Satellite Business Model

a) The SBP shall procure the end user equipment from OEM / manufacture the end user equipment in India for supplying to end customers. The end user equipment should be compatible with the BSNL's GSPS Gateway and the bidder shall obtain necessary approval(s) from concerned authorities of Government for manufacturing the end user devices in India. The SBP shall do marketing and selling of the end user devices & services and generate the business.

b) The SBP shall invest the capital required for the proposed business. BSNL will not invest any money.

c) There will be revenue share arrange between BSNL and the SBP for sharing revenue earned from the sale of the end user equipment and service(s).

d) The Satellite resources will be provided by BSNL. The service provisioning will be done by BSNL, for which necessary support will be provided by the SBP.

e) The support services to end user will be provided by the SBP.

f) The SBP will setup billing platform, if needed. g. The tariff and commission structure for the services will be finalized by BSNL in consultation with the SBP and based on the business plan of the SBP.

g) The SBP shall provide only such service/(s) for which he will be authorized by BSNL.

h) The SBP shall provide maintenance, repair and warranty support for the end user equipment to end customers.

i) The SBP shall provide customer care on a 24 x 7 basis to all the customers who utilize the Services.

j) The SBP must follow and must require End Customers to follow the procedures ("Procedures") established by the entities that supply the Services and Equipment. The SBP acknowledges that the Procedures may be modified from time to time by BSNL. BSNL will provide SBPs with a copy of the applicable Procedures upon execution of the Agreement and at any time when the Procedures are modified.

k) The SBP shall obtain Customer Acquisition Form (CAF) from customers and handover the completely filled CAF to BSNL before providing services to new customers.

l) The SBP shall support BSNL in realisation of bills from customers and also in the take-up and growth of these services in India.

m) The SBPs are required to be technically and financially capable and therefore able to operate in the market in a fairly autonomous manner. However, it should be noted that BSNL is committed to make this business a success and, as such, will provide support as requested to make our joint business a success.

n) The SBP will be required to submit an initial and thereafter an annual Business Plan in which, as a minimum, they will need to specify which types of users they will be seeking to secure business from, what investment or resources they will be devoting to this activity, what level of sales they are forecasting over a rolling 3 years period and what support they would like to have from BSNL and Inmarsat.

o) Regulatory approval, if required will be obtained by BSNL and the SBP shall provide full support to BSNL for the same.

13.8 M2M/IOT

a) BSNL invites proposal, on Revenue sharing basis from M2M Partners, from interested and eligible firms/ companies for association with BSNL to generate revenues from M2M (Machine to Machine) projects being undertaken by Government/ Autonomous and Commercial entities all across the country. M2M partner or its principal may meet the relevant eligibility criteria in combined manner. The purpose of this policy documents is to empanel M2M partners for exploring and executing M2M business opportunity jointly. BSNL may enter into the agreement with Non-exclusive arrangement with M2M partner based on specific requirements of projects. The empanelled M2M Partner shall be called "Centrally Empanelled M2M Partner" i.e. CEMP and shall be eligible for partnering BSNL across its area of operation. Empanelled vendors, if selected for execution of a M2M project may enter into the separate agreement with BSNL Circles for execution of the project.

b) BSNL is currently operating its GSM mobile services across the nation except in Delhi and Mumbai and have a subscriber base of more than 105 million. BSNL also have a

landline subscriber base of 13 million. BSNL is providing different Value Added Service on SMS, MMS, GPRS, EDGE and 3G etc to its Cellular customers. BSNL is envisaging to progressively generating revenues from M2M and associated services, which may require partnership with external agencies acting as Technology provider, Device Manufacturers, Application Developers, Field Support Providers, and System Integrators etc. The technology shall enable transactions through SMS, GPRS, USSD, WAP, J2ME and Internet etc.

c) The M2M partner shall be required to establish a platform preferably in Disaster Recovery mode & according to latest Regulatory Guidelines including TRAI QOS requirements, if applicable. It is expected that the M2M partner approaching BSNL for partnership in this business shall be aware of the revenue streams/costs involved/business case of this business and shall have sufficient knowledge and resources to operate the services. The M2M partner is expected to rope in all partners essential for end to end delivery of services to customers.

d) One of main requirement is linking up with other players in the value chain to provide a solution that meets the precise needs of the customer within many sectors and markets including Automotive, Consumer Electronics, Consumer Goods, Energy & Utilities, Financial Services, Health, Manufacturing, Public Services, Security Transport & Logistics etc. The Ecosystem of M2M business should have below mentioned stakeholders and M2M partner should be capable of performing all (except providing telecom Connectivity) activities involved in end to end delivery of M2M value chain, but limited to following:

a) M2M Device Provider
b) Connectivity Provider
c) Service Management Platform Provider
d) Application Middleware provider
e) Managed Service Provider
f) Field Support Provider
g) Application Provider
h) Infrastructure Provider
i) System Integrator

13.8.1 Responsibility of BSNL

a) BSNL will do interaction with enterprise customer individually or jointly with M2M partner.

b) BSNL will provide telecom connectivity to M2M PARTNER for installing M2M solution as per requirement of Enterprise customer. Types of connectivity are E1 connectivity for SMSC, PRI connectivity for voice response system & WAP connectivity, Broadband connectivity for Internet etc.

c) BSNL will provide Short codes, Long Codes & Access Point Name (APN)s for SMS, USSD, IVR etc.

d) BSNL will provide Subscriber Identity Module (SIM) for M2M solution as per requirement of Enterprise customers.

e) BSNL will prepare special tariff plans for M2M Enterprise customers as per requirement and feasibility.

f) BSNL may use man-power for field support for day to day operation & Maintenance (O&M), if required and feasible.

g) BSNL will provide support for network related problems.

h) Hosting Infrastructure: Infrastructure including AC/ Power/ space / connectivity to local BSNL Network etc. shall be provided by BSNL for this business in case deployment is done in BSNL Premises.

13.8.2 Responsibility of M2M Partner

The M2M partner shall be responsible for complete implementation of M2M solution, which includes survey, design, engineering, supply, testing, packaging, transportation, erecting, successful commissioning, putting into operation and establishing the successful performance during the period of agreement with customer and comprehensive O&M (including warranty etc.). Complete implementation means full responsibility to implement M2M solution for customer as specified by them. Further comprehensive O&M means full responsibility to undertake effective & efficient Operation & Maintenance activities as specified. This includes all incidentals/ services/ materials/ manpower/ permissions/ liaison/ licences/ spares/ consumables etc., whether explicitly listed or implicitly required for the satisfactory completion and performance of the System as per the specifications, meeting international codes and standards.

13.9 CONCLUSION:

In this chapter we have discussed, .how we can increase the ARPU for BSNL, in this competitive market by exploring the New businesses so as to raise the revenues.

14 SIP, EPABX AND BULK SMS

14.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand:

- Session Initiation Protocol (SIP)
- EPABX
- Bulk SMS

14.2 SESSION INITIATION PROTOCOL

14.2.1 Introduction

SIP (Session Initiation Protocol) is a signaling protocol used to create, manage and terminate sessions in an IP based network. . Session Initiation Protocol (SIP) is an application-layer control (signaling) protocol for creating, modifying, and terminating sessions with one or more participants. These sessions include Internet telephone calls, multimedia distribution, and multimedia conferences.SIP has been the choice for services related to Voice over IP in the recent past. It is a standard (RFC 3261) put forward by Internet Engineering Task Force (IETF). It SIP is still growing and being modified to take into account all relevant features as the technology expands and evolves. But it should be noted that the job of SIP is limited to only the setup and control of sessions. The details of the data exchange within a session e.g. the encoding or codec related to an audio/video media is not controlled by SIP and is taken care of by other protocols.

14.2.2 A Brief History of SIP

Initially only the traditional switch-based telephone system was the main medium for transmitting messages. However with advent of the Internet, need was felt to fabricate a system, which connects people over the IP based network. Different communities put forward different solutions but the solution presented by IETF was finally accepted as most general one. February 1996 Initial Internet drafts were produced in the form of - Session Invitation Protocol (SIP), Simple Conference Invitation Protocol (SCIP). SIP was originally intended to create a mechanism for inviting people to large-scale multipoint conferences on the Internet Multicast Backbone (Mbone). At this stage, IP telephony didn't really exist. The first draft was known as "draft-ietf-mmusic-sip-00". It included only one request type, which was a call setup request. January 1999 The IETF published the draft called "draft-ietf-mmusic-sip-12". It contained the six requests that SIP has today. March 1999 SIP published RFC 2543 as a standard. It was modified further to generate the more modern version of RFC 3261.

14.2.3 Functions of SIP

SIP is limited to only the setup, modification and termination of sessions. It serves Five major purposes.

a. User location: determination of the end system to be used for communication;

b. User availability: determination of the willingness of the called party to engage in communications;
c. User capabilities: determination of the media and media parameter to be used;
d. Session setup: "ringing", establishment of session parameters at both called and calling party;
e. Session management: including transfer and termination of sessions, modifying session parameters, and invoking services.

14.2.4 Components of SIP

SIP is a signaling protocol that handles setup, modification, and termination of multimedia sessions. Though SIP messages will be transported through the same physical path as used by Media stream, SIP Signalling should be considered separately from the media. SIP messages can pass via one or more servers to find out destination address, on the other hand Media stream will be direct i.e. end to end.

SIP defines two basic classes of network entities : client and server. A client is any network element that sends SIP requests and receives SIP responses. Clients may or may not interact directly with a human user. A server is a network element that receives requests in order to service them and sends back responses to those requests. Four different types of servers exists: proxies, user agent servers, redirect servers, and registrars.

Proxy Servers: An intermediary entity that acts as both a server and a client for the purpose of making requests on behalf of other clients. A proxy server primarily plays the role of routing, which means, its job is to ensure that a request is sent to another entity "closer" to the targeted user. Proxies are also useful for enforcing policy (for example, making sure a user is allowed to make a call). A proxy interprets, and, if necessary, rewrites specific parts of a request message before forwarding it.

Redirect Servers: A redirect server is a server that accepts SIP requests, maps the destination address to zero or more new addresses and returns the translated address to the originator of the request. After that, originator will contact on given addresses directly.

Registrar: A registrar is a server that accepts REGISTER requests and places the information it receives in those requests into the location service for the domain it handles. As one machine / software can work as UAC or UAS depending upon the transaction in which it is engaged same is equally applicable for servers. Similarly, the same software can act as a proxy server for one request and as a redirect server for the next request. Proxy, location, and registrar servers defined above are logical entities; implementations may combine them into a single application.

SIP Protocol Operation

SIP is a text-based protocol, similar to HTTP (Hypertext Transfer Protocol). SIP messages are either request from a client to a server or responses from a server to client. Each message, whether a request or response, contains a start line followed by zero or more headers and is optionally followed by a message body. Message headers provide additional information regarding the request or response. The message body describes type of session to be established, including a description of media to be exchanged. It is important to mention that SIP does not define the structure or content of message body. It is defined by other

protocols like SDP(Session Description Protocol). The job of SIP is to carry that description upto destination.

SIP Request: A SIP request consists of a request line, headers, an empty line and a message body. A Request-Line contains a method name, a Request-URI, and the protocol version. The method name indicates the type of request. The core SIP specification defines six types of SIP requests, each of them with a different purpose.

The Request-URI indicates the next hop, which is where the request has to be routed. URI (Universal Resource Identifier) is an address and in the form of user@host, which is similar to an email address. It may look like : " SIP: xyz@bsnl.co.in". Finally the protocol version of SIP is 2.0. Hence, one INVITE request may have the following format:

INVITE sip:xyz@bsnl.co.in SIP/2.0

Table -1 SIP Message

Command	Meanings
INVITE	Invites a user to a call
ACK	Acknowledgement is used to facilitate reliable message exchange for INVITEs
BYE	Terminates a connection between users
CANCEL	Terminates a request, or search, for a user. It is used if a client sends an INVITE and then changes its decision to call the recipient.
OPTIONS	Solicits information about a server's capabilities.
REGISTER	Registers a user's current location
INFO	Used for mid-session signaling

SIP Response: A SIP response consists of a status line, several headers, an empty line and a message body. The message body is optional; some responses do not carry it.

Status Line: A status line has three elements: protocol version, status code and a reason phrase. The current protocol version is written as SIP/2.0. The status code reports transaction status. Status codes are integers from 100 to 699 and are grouped into six different classes. The reason phrase is meant for human eyes only. It is not meant for computers processing SIP response.

Table 2 Shows the response group, their descriptions and examples:

Response Code	Description	Example
1xx	Informational – Request received, continuing to process request	180 Ringing 181 Call is being forwarded
2xx	Success – Action was successfully received, understood and accepted.	200 OK
3xx	Redirection – Further action needs to be taken in order to complete the request	300 Multiple choices 302 Moved temporarily
4xx	Client Error – Request contains bad syntax or cannot be fulfilled at this server	404 Not found 408 Request timeout
5xx	Server Error – Server failed to fulfill an apparently valid request	503 Service unavailable 504 Version not supported
6xx	Global failure – Request is invalid at any Server	600 Busy everywhere 604 Does not Exist anywhere

SIP Headers: SIP Headers are included in a request / response in order to provide further information about the message. Depending on the request/response certain headers are mandatory, some headers are optional and some headers are not applicable. Four main categories of header exist:

General Header: General Headers can be used within both requests and responses.

Examples are-

To Header: It indicates recipient of the request. It is important to make a distinction between To header of a request and Request – URI. The To Header is intended for the actual destination UA. Proxies cannot change it. On the other hand the Request – URI is the address of next hop in the signaling path and is therefore changed by every proxy.

From Header: It indicates the originator of the request.

Call – ID: It uniquely identifies a specific invitation to session.

Request Headers: Request Headers apply only to SIP request and used to provide additional information to the server regarding the request itself or regarding the client. Example: Subject header, which is used to describe a textual description of the session.

Response headers: They apply to responses only to provide further information regarding response.

Example: Retry after header, which can indicate when a called user will be available in case called user is busy or unavailable.

Entity Header: In SIP, the message body contains information about the session or information to be presented to the user. The purpose of entity header is to indicate type and format of information included in the message body, so that appropriate application can be called upon to act on the information within the message body.

Example: Content- Length: It indicates the length of the message body in octets.

Basic SIP Operation:

Basic SIP operation is the transaction of REQUESTs and RESPONSEs. Client generates SIP requests, server receives those requests and returns responses. The basic SIP operation starts with a SIP INVITE (request) message, which is generated by calling party. The message invites the called party to participate in a session i.e. a call. After reception of INVITE called party UA can generate different responses like ringing, busy, queuing, OK etc. For instance called party UA returns ringing. ubsequently, when called party answers the call, this UA will generate OK response. The calling client

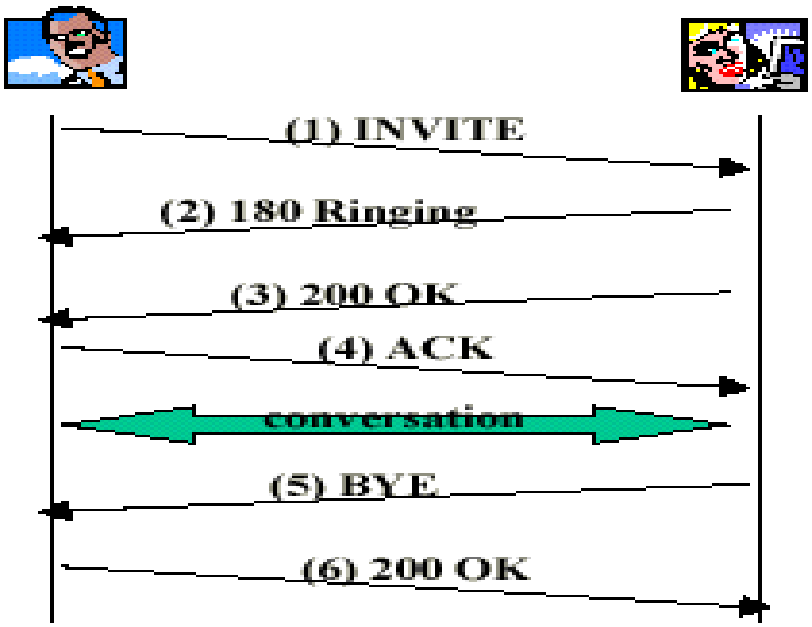


FIG. 1 Example of SIP messages.

acknowledges that the called party has answered by issuing an ACK message. At this point, media (voice, data, video) are exchanged. Finally, one of the parties hangs up, which

causes a BYE message to be sent. The other party UA sends OK response. At this point, the call is over.

14.2.5 SIP trunking

To put it simply, SIP trunks are virtual phone lines that allow making and receiving calls over the internet to anyone in the world who has a phone number. SIP stands for Session Initiation Protocol, a popular telephony protocol that initiates calls over the internet and is primarily used to manage multimedia communications, like voice and video calls. SIP establishes and terminates the connection for a phone call, controls the transfer of data, and is what enables services like Skype and Facebook Messenger to provide free calling anywhere around the world.

A "trunk" is a line or link that carries signals and connects nodes in a communications system. In other words, it is a pipe that carries the data channels inside it to connect two locations.

SIP trunking is a method of sending voice and other communications over the internet through an IP-enabled private branch exchange (PBX), which is a telephone system within an enterprise that switches calls between users on local lines while allowing them to share the use of external phone lines. A PBX cuts down on costs by avoiding the need for each user to have a line to a telephone company's central office. SIP can be used to send and receive local and long- distance calls, text messages, and emails; browse the internet; and conduct video chats.

a. SIP trunking is a telephony protocol that makes calls over the internet by establishing and controlling the transfer of data.
b. SIP trunking can significantly cut costs and increase reliability for your business phone system.
c. To determine if SIP trunking is the right service for your business, you need to research and carefully assess your business's communication needs.
d. SIP trunking pricing is based on several factors, like your vendor and add-on features.

SIP trunking replaces the traditional method of the public switched telephone network (PSTN), which is a copper-wire, circuit-switched network that requires a physical connection between two points to make a call. Instead, SIP trunks use a packet-switched network, which breaks down voice calls into digital packets and sends them over a network to their destination.

SIP channels

Each SIP trunk can hold an unlimited number of channels. A channel, or line, is equivalent to one incoming or outgoing call. Because each trunk can hold as many channels as necessary, a business would only need one SIP trunk – no matter how many calls you have coming in and going out at one time. The more phone calls you have to run concurrently, the more trunk channels you will need.

14.2.6 Benefits of SIP trunking

The greatest benefit of using SIP trunking as your business phone system is that it is highly cost-effective. This is due to many reasons, but mainly because it eliminates the costs

of long-distance calling. If your business often makes phone calls across the country or the ocean, SIP trunking may be the answer for you.

Centralized network

SIP also eliminates the use of both data and telephone voice networks. Because SIP is IP-based, you can enjoy one centralized network with multiple digital streaming capabilities that is easily scaled and requires no physical infrastructure, which means no maintenance or hardware costs.

The removal of the PSTN gateway allows the SIP trunk to connect directly to your chosen internet telephony service provider (ITSP), removes subscription fees, and gives you greater flexibility in how you scale your telecommunications services by providing more bandwidth increment options at lower rates.

Local call charges

A SIP trunk enables all calls to be local calls by carrying them over the internet, avoiding the costs of international or long-distance calls. The SIP trunk sends the call to the provider's termination point, where the call is transferred to a local PSTN, therefore only charging you for a local call.

To compete with ITSPs, many SIP trunking providers have added services such as ENUM, or telephone number mapping, which allows you to use the same phone number no matter where you are in the world. They also offer the elimination of 800 numbers by providing a local number based on your location.

Scalability

SIP trunking is flexible and easily scalable, with an unlimited number of channels allowed per trunk and no physical installation or setup necessary. New channels can be added and enabled within hours.

Disaster recovery

SIP trunking services tend to be far more flexible and resilient than legacy phone systems in a disaster Whether it's a network failure, natural disaster or hardware problem, most services will have measures in place to make sure you can still place calls. These may include geographic redundancy, routing calls to different locations or data centers, or dispersed network operating centers.

Your SIP trunking service will also help you create a disaster preparation plan on your end, including steps such as routing your calls to a different predetermined number, using a backup trunk provider, or having a cloud system ready for backup.

14.3 EPABX

A lot of organizations incorporate the **EPABX system** for internal as well as external telephonic communication. EPABX stands for Electronic Private Automatic Branch Exchange which is a private telephone network used by the organizations and the companies for various types of communication, either between the employees or outside the clients. PBX which is Private Brand Exchange is a telephone exchange which is used by a particular office or business, opposite to the one that a common carrier or telephone company operates

for many companies and businesses for the general public. Private Branch Exchange **(PBX)** is also known as **(PABX)** Private Automatic Branch Exchange and **(EPABX)** Electronic Private Automatic Branch Exchange.

EPABX is essential equipment that has made daily working in the offices and organizations much smoother and simpler, especially the area of communication. This system is a switching system which has enabled both internal and external switching functions for any organization. To select an appropriate EPABX one need to have proper knowledge about the traffic pattern inside the office. With the right utilization of the EPABX, all the internal and external requirements of the organization are adequately served. With the advancement in the field of computers along with the advent of microprocessors, the EPABX incorporates a lot of helpful features. The boss can establish a hotline with his or her immediate subordinates.

The call transferring and forwarding feature has enabled the mobility of the users. Automatic redialing of numbers and auto conferencing has initiated engagement which is also one of the advancements in the characteristics of the EPABX. A proper survey of the organization should be done before the selection of an EPABX for the particular company. The exchange should incorporate a supporting system such as voice DISA-n-auto attendant. This feature is of great help to attendants and receptionist. The further specifications of this system should ensure inbuilt paging, auto fax homing, hot outward dialing, remote dialing; auto shut dynamic shot, as well as remote servicing.

How does this system work?

This telephone system helps businesses to cut cost by using a private branch exchange. With the help of this system, businesses aren't required to run a line from every phone in the building to the telephone company's central office. The PBX Setup: Initially during the 20th century, PBX used to run on analog technology, but today it has gone digital. The typical private branch exchanges incorporate several phone lines from outside the building which terminates at the company exchange. It also includes several internal lines that lead to the exchange for the inside phones. A computer is used that manages the calls and switches them to one line to another based on the number dialed. This digital PBX doesn't require a human operator.

VoIP for PBX:

VoIP technology is Voice over Internet Protocol, and some of the exchanges rely on this technology. This system turns phone calls into data packages and then sends them over a computer network. As compared to regular PBX, a VoIP cuts the extra cost because the company can use one network for phone calls and data instead of two. PBX has a central server and not a central switchboard. The phones in the office have particular software and hardware to connect to the server.

Virtual PBX: Business is not required to set up the exchange inside the building as virtual PBX turns that responsibility over to another company. When the other company provides PBX services, it brings along a lot of advantages. You are not restricted to any physical limits on the number of lines and can get more when needed. The virtual PBX is also known as hosted PBX systems.

Private Branch Exchange - PBX

PBX systems are private local **telephone systems** that are used to provide telephone service within a building or group of buildings in a small geographic area. PBX systems contain **small switches** and advanced call processing features such as speed dialing, call transfer, and voice mail. PBX systems **connect local telephones** ("stations") with each other and **to the public switched telephone network (PSTN)**.

This diagram shows a private branch exchange (PBX) system. This diagram shows a PBX with telephone sets, voice mail system, and trunk connections to PSTN. The PBX switches calls between telephone sets and also provides them switched access to the PSTN. The voice mail depends on the PBX to switch all calls needing access to it along with the appropriate information to process the call.

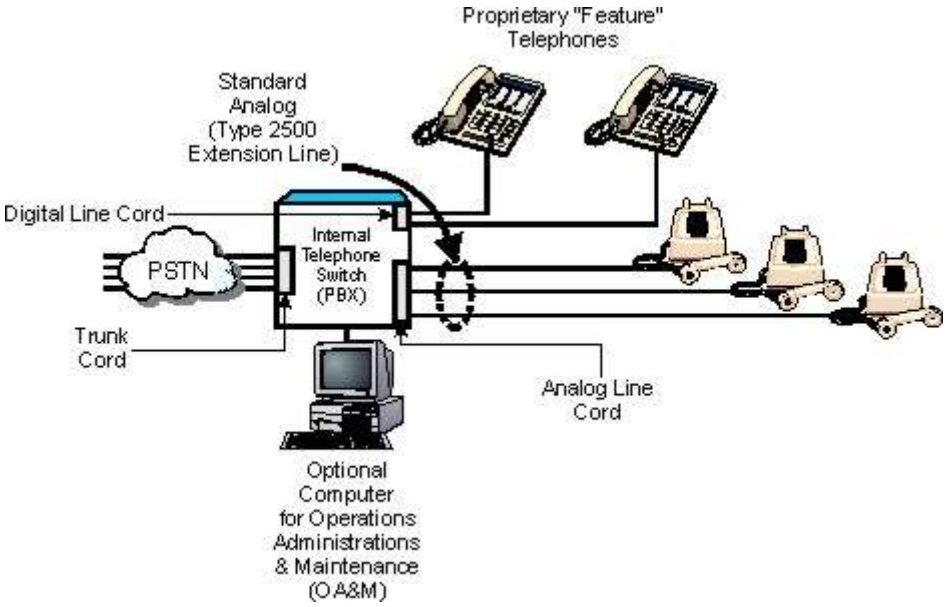


FIG:2 Private Branch Exchange - PBX Diagram

EPABX specifications / features

Following typical specifications need to be considered while purchasing EPABX system from manufacturers or any installation service providers.

a. It should support voice over IP to provide voice communication over IP network.

b. It should support IP extensions, IP trunk in addition to PCM/TDM capacity.

c. It should have following interfaces supported on EPABX system:

-Analog Public Network (P&T lines)

-ISDN Public Network (BRI /PRI/E1R2/T1)

-Private Network of E&M

-LD Trunk as well Lease Line

-Optical

d. Loop Start DP and DTMF Signaling with Pulse detection

e. ISDN compatibility

f. 2 Wire & 4 Wire interface

g. It should provide CLIP feature in all the extensions & analog trunks.

h. It should support DECT handset as well as WiFi handsets

i. It should have VAD (voice activity detection) and AGC (automatic gain control).

j. It should support voice mail

k. It should support G711 and G729 compression standards

l. It should support multi party conference

It should support secure conversations i.e. should support RTP, SIPs with TLS (Transport Layer security) protocols

14.4 BULK SMS

Bulk SMS Service refers to sending SMS to large number of people at the same time. It is the text messages sent to a large number of recipients at once. Text Messages sent in bulk are called as Bulk SMS. SMS messages are bought and sent in bulk, so the term Bulk SMS was the best to use since it describes this service immediately. Bulk SMS is a service that enables sending a large number of SMS messages to a broad audience at once. It is used by businesses to promote their brand, send important notifications and establish market credibility. In today's competitive environment, it gets difficult for business owners to engage clients on a deeper level.

SMS may be person to person or application to person. Bulk SMS messaging is a legacy description for application-to-person SMS messaging services. It refers specifically to the sending of large number of SMS messages to the mobile phones of a predetermined group of recipients. Today the application-to-person SMS messaging services have evolved to include bulk SMS messaging alongside the sending of single messages (Such as one time passwords and delivery notifications), interactive messaging (such as group messaging services), and incoming number services (Such as mobile marketing campaigns, voting or information lines).

A defining characteristic of bulk SMS messaging is that businesses and organisations can make use of one or more solutions to send and receive SMS messages, namely; a mobile phone application, software program, a web interface, or integrate an SMS API with their website or system. These bulk SMS messaging solutions interface with a Service Providers' SMS gateway to ensure the delivery of messages to mobile phone numbers anywhere in the world.

Since messages are bought in bulk, they are much cheaper than regular text messages used on an individual mobile phone for personal communication with other people. In the same time, Bulk SMS is cheaper and significantly more effective than e-mail and e-mail marketing.

Bulk SMS is one of the fastest ways of interacting with your target audience in a reasonable and efficient manner. With the highest open rates and speedy delivery, SMS Service has surpassed the traditional conventional tools and emerged as the most popular communication channel for every industry and organization.

Bulk SMS Service is used by industries, companies, organizations to communicate with their customers and also for promoting their business. There are numerous terms denoting Bulk SMS Service. It is also called Text Messaging Service, Bulk Messaging Service, Business SMS, Bulk Texts etc.

Bulk SMS is a widely used medium for staying in touch with the clients and connecting with them on a personalized level. It just needs to register with a Bulk SMS Provider then it can start sending SMS without any formalities. Nowadays, SMS Service has become a popular tool for businesses. As SMS feature is supported by every mobile device, it allows business owners to spread their brand awareness and connect with a diverse range of customers anytime, anywhere.

This is a super powerful service to use in your business to deliver SMS messages safely, quickly and directly to your customers worldwide. If any organization is in competitions, marketing campaigns, notifications to employees, promotions or events; bulk mass messaging is the best platform to use for sending out a high volume of messages in one go.

The uses of bulk SMS messaging is continually evolving as new business or public benefit needs are identified. From large scale businesses to small enterprises, community groups to educational institutions, bulk SMS messaging provides a cost effective solution for managing communications with small or large contact groups.

Types of Bulk SMS

Bulk SMS have been categorized mainly into

- Transactional
- Promotional

Promotional route is for the purpose of advertising and marketing of a brand or a business. Businesses can use this route for sending offers, discounts, coupons, free gifts passes, seasonal discounts and festive sales. Messages from this route can only be sent to the Non DND numbers from 9 AM to 9 PM.

Transactional route is for sending informative messages related to products, services such as purchase confirmations, login OTP, booking updates, payment alerts, delivery notifications, etc. This route can only be used for sending crucial notifications to DND and Non DND numbers 24/7.

However, in the new TRAI regulations, new SMS categories have been introduced such as

- Transactional
- Service Explicit
- Service Implicit
- Promotional

Before commencing with the sending bulk SMS messages it is important to note that you must comply with the regulations specific to your country and the country to which you are sending SMS messages.

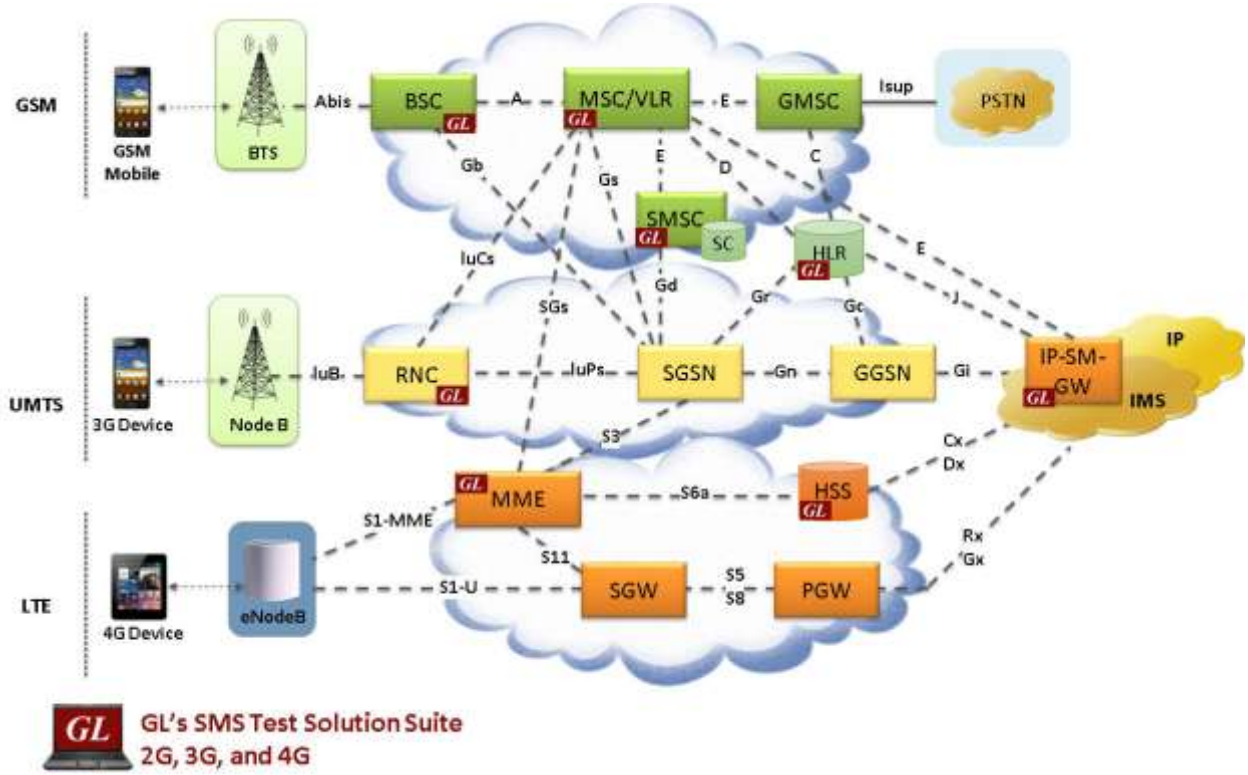


Fig:3 Network Diagram for routing SMS

Bulk SMS messaging service is ideal for advertising and marketing agencies, retailers, B2B businesses, financial institutions, banks, travel companies, and agencies or any type of business/organization that wants to create a customer list to reach and inform them on a regular basis. This will help each of them in earning customers' loyalty. In the same time, SMS Bulk messaging service provides its users' capability to communicate rapidly with large numbers of people, so it can be used 'externally' (marketing campaigns, informing clients of deals and promotions, competitions, etc.) or 'internally' (within the company, to send notifications to employees).

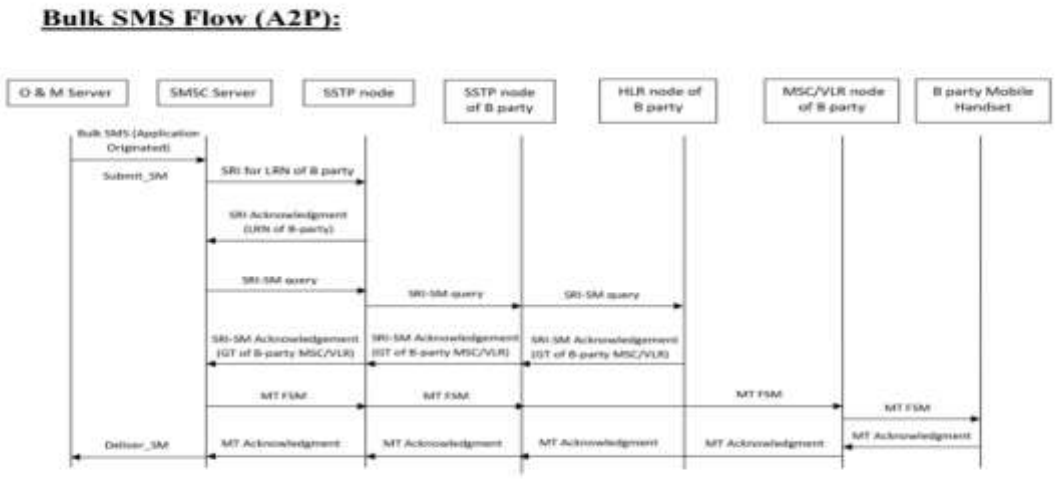


Fig:4 Bulk SMS flow(A2P)

The beauty of Bulk SMS lies, in fact, it's so easy to use. You just need to select your provider (HORISEN for instance), create your account, upload your list of clients, provide text message you want to send and just click 'Send.' And that's it. In just a matter of seconds, your clients will receive the update you sent to them. And you'll get the online access to statistics and reports in real time that will help you overview results to make successful marketing decisions in the future.

Communication done this way is far more affordable and cheaper, providing a higher return on investment. And it is far more convenient too. Just imagine the time, effort and amount of money needed to communicate with your customers using some of the more traditional manners of communication, like cold calling. A disastrous way of business-to-client communication and even worse marketing! Then just compare this with an automated action when you send the same marketing message to all these people in just a second — no waste of time, no waste of money, no waste of resources and at the end, great results since you're not harassing people. Those receiving your SMS notifications or SMS newsletters are those who opted-in to receive them.

Bulk SMS is a great lead generator and a prospecting tool since it enables businesses to reach out to and stay in touch with people who showed interest in their services/products. But, even if people opted-in to receive notifications, the process is far from finished. One of the reasons why this type of communication is so successful lies in a fact that more than 90% of text messages get read within 3 minutes of delivery. No other communication channel can brag to have such a success rate.

Simply put, this type of mobile communication provides easy access to clients/consumers, because all statistics say that mobile phone is most commonly used device today. Some data say 91% of adults keep their smart phones within arm's reach. Some other data even say that four out of five smart phone users check their phones within the first 15 minutes of waking up. 80% of those say it's the first thing they do in the morning. Another

interesting fact is brands using SMS successfully reach 95% of smart phone and non-smart phone users. Source: GoMoNews.com

Immediate benefits coming from sending SMS in bulk are:

- Competitive advantage
- Low operational costs
- Revenue generator
- Measurable ROI
- High efficiency
- Good value for money

SMS Services have bridged the communication gap between the business and the customers. Every message reaches directly to the recipient's mobile phone and gets read utmost within 3 minutes. SMS Messaging has become a widely used communication channel among plethora of industries such as e-commerce, retail shops, educational institutions, restaurants and many others.

Common uses of Bulk SMS

- Sending alerts
- Sending offers
- Sharing festive deals
- Transmitting updates
- Sending OTP
- Verification codes
- Advertising campaigns
- Promotional SMS
- Free gift coupons
- Purchase orders
- Product Tracking details
- Transit status
- Payment confirmations
- Booking updates
- Login details
- Account status and updates

Common Industries using SMS Service

- Banks and Financial Institutions
- Advertising Agency
- Corporate houses
- Educational Institutes
- Retail Industry
- Shopping portals
- Logistics and Courier services
- Travel Agency
- Automobile
- Healthcare Industry
- Real Estate Sector

- E-commerce Portal
- Hotel Industry

Key Benefits of SMS

- Economical: Starting with a Bulk SMS Service is affordable. No fixed budget is needed. SMS is the lowest costing advertising channel that has the capacity to generate highest returns on investment. SMS has a number of plans that cater to the equirements of every business. With a nominal budget, you can carry out your campaigns and even send crucial notifications in a time-bound manner.
- Easy to implement: Technical knowledge is not needed to operate an SMS panel. It is user-friendly and can be managed by any person without any special skills.
- Suitable for every business: As it is a flexible, reliable tool with highest returns, it is popular among both large and small scale industries. Having an extensive range of SMS plans makes it ideal for every industry and organization.
- Instant: It helps in instant communication with the target customer group. SMS gets delivered in the fastest speed which is not possible with any other communication medium. It allows businesses to connect with a broader audience in just a few seconds.
- Higher response: It has been proven that the readability and response generated from Bulk SMS campaigns are higher than any other channel. Emails have open rate of 22%, cold-calling is no longer prevalent and other social media channels such as Facebook, Instagram campaigns require internet availability. SMS has the highest open rate of 98%.

Moreover, it is suitable for every business in spite of size and nature of the firm as SMS campaign can be started with a small amount of money. Internet availability is not required to view a text message. Hence, it provides a wider reach than other tools. A single message text can be sent to millions of clients at once. SMS Marketing allows a firm to promote its brand to a large number of people simultaneously. SMS feature does not require an app download or installation. It is present in every phone whether it is a smart phone or a traditional phone. Therefore, brands prefer Bulk SMS Services as it allows them to cover a wide area in the shortest time span.

Advantages of Bulk SMS Service in finger tips

- Most reasonable tool for creating brand recognition
- Has the highest open rate of 98%
- Delivers in a few seconds
- Enables businesses to connect with their clients speedily
- Provides a wider reach
- Easy integration
- Reliable channel for transmitting crucial information
- Convenient to integrate

This bulk SMS messaging becomes so popular day by day because it’s so easy to use and it is supported on all mobile phones regardless of being smart phones or featured phones.

Everyone can send and receive text messages, this simple technology doesn't require any specific knowledge or technical 'literacy', nor does it require an internet connection. This is the reason why bulk text messaging service is the ideal communication channel to reach out and connect to customers. So, if know all these, not using this incredible power of bulk SMS is one of the worst 'business sins' today.

14.5 CONCLUSION:

In this chapter we have discussed, how SIP (Session Initiation Protocol), signaling protocol can be used to create, manage and terminate sessions in an IP based network, utilization of EPABX and Bulk SMS services.

15 TIP AND FRANCHISEE MANAGEMENT

15.1 LEARNING OBJECTIVE

After reading this unit, you should be able to understand services managed by Franchise/ TIP:

- Enterprise Wi-Fi service
- Establishment and Maintenance of Customized Wide Area Network (WAN)
- PABX
- Network System Solution
- Bulk SMS solution etc.

15.2 INTRODUCTION

With the objective of increasing the customer base and enterprise business of BSNL and to utilize the channels already associated with BSNL for sales, marketing and delivery in various segments TIP (Telecom Infrastructure Provider) and Franchisee is introduced.

The channel partners would require to identify the prospective Business & Customers and to convert such prospects (Leads) into a business order by regular visits, presentations, submissions and explaining the various services and plans to them and to convince them to bring them on board for taking BSNL services. The channel partners succeeding in garnering business for BSNL would get suitable remuneration in the form of payment of commission depending upon the category of customer, type of product(s) and volume of business booked.

Some Enterprise Business which is managed by Franchisee/TIP is listed below:

a. Enterprise Wi-Fi service
b. Establishment and Maintenance of Customized Wide Area Network (WAN)
c. PABX
d. Network System Solution
e. Bulk SMS solution etc.

Details scheme of above mentioned Enterprise solution is discussed one by one.

15.3 ENTERPRISE Wi-Fi SERVICE

BSNL is providing Telecommunications services to Enterprise customers such as Government customers, PSUs, MNCs, Educational Institutions & other customers. There is large scope of business opportunity to provide Wi-Fi hotspot services for these customers.

BSNL has deployed Wi-Fi core system with main at Bangalore and DR at Pune BSNL. Corporate Office has instructed all the telecom circles to engage public Wi-Fi providers for providing Wi-Fi services under Bulk user plan to Enterprise customers on revenue share basis.

15.3.1 Enterprise Wi-Fi Model

a. Public Wi-Fi Providers/ Partners (PWPs) shall be permitted on first come first served basis as per the requirement of SSAs/ Circles.
b. The PWP can deploy the Access Points APs both Indoor and Outdoor using the available models (including RAPs with mesh APs).
c. Public Wi-Fi Provider (PWP) shall supply, install commission, operate and maintain the PoEs/APs/UPS in customer premises.

d. BSNL Reserves the right to broadcast its own SSID Other than captive traffic in further with addition additional bandwidth provision.
e. The required bandwidth for provisioning of bulk user plans shall be bundled with the various plans. Beyond this bandwidth, incremental BW charges shall be applicable for which BSNL will raise separate invoice to the bulk customers.
f. Internet shall be unlimited.
g. Captive portal for customer authentication shall be customized as per client requirement. SSID will be configured as per the Clients/Partner's choice.

15.3.2 Responsibility of Public Wi-Fi Partners (PWPs)

a. The Public Wi-Fi Partners engaged through this open policy shall supply, install, commission, operate and maintain Wi-Fi Hotspot location equipment such as Access Points (which may be indoor or outdoor), UPS, POE, racks and associated installation materials at hotspot locations.

b. BSNL shall extend bandwidth as per tariff plans purchased by customer. The Public Wi-Fi Partner shall be responsible for extending the Bandwidth connectivity from this single point to the remaining access points at that hotspot location including electrical wiring staring from UPS, Optical, Data, LAN cabling etc.

c. Access Points (APs) shall be integrated with OEM's WLC and create CAP/WAP tunnel as per standard CAP/WAP protocol.

d. The PWP shall plan the hotspot locations by site survey, plan logistics etc. and get the acceptance testing etc completed.

e. The Wi-Fi partner will be fully responsible for the operation and maintenance of HS/APs/PoEs/WLCs/EMSs being deployed under this partnership and shall have back to back arrangement with OEM of AP/WLC.

f. Details scope of work regarding installation of Wi-Fi Hotspot, Integration details of WLCs with BSNL's existing WAG/DHCP and integration of EMSs/CMSs shall be discussed and finalized with the Wi-Fi NoC team at the time of validation/testing.

g. **Promotion and Marketing of service –** Public Wi-Fi Partners shall proactively market Wi – Fi services by educating the customer on the usage /benefits of the service and BSNL tariff plans etc.

h. The Public Wi-Fi partner shall carry – out formalities for Customer acquisition, assisting customers in filling up of CAF (customer acquisition form).

15.3.3 Responsibility of BSNL.

BSNL shall provide space and power at Central location for Installation of WLC/EMS free of cost. No co-location charges shall be taken from the OEM/Authorized partner of OEM.

a. The B/W or backhaul shall be bundled by BSNL as per the bulk user plan.

b. BSBL shall be responsible for integration of WLC/EMS with BSNL Core,

c. Provisioning and Billing shall be BSNL's responsibility.

d. BSNL shall provide necessary support to the PWP/OEM/authorized OEM for integration with BSNL Core network, marketing strategies and use of prepaid Wallet system etc.

15.3.4 Eligibility Requirement for Public Wi-Fi Partners (PWPs)

a. Any registered/partnership/proprietorship firm/society including existing Telecom Infra Provider, having, minimum turnover of Rs. 5 Lakhs per year during the last three consecutive years shall be eligible.

b. The registered/partnership/proprietorship firm/society shall have worked with Telecom Service provider(s) /ISP(s) for minimum 1 year.

c. Existing FTTH Franchisee with good record of providing FTTH connections/BSNL service shall be eligible to become Public Wi-Fi Partners.

d. One time Registration charges of Rs. 10,000/- (non-refundable) and applicable. Taxes shall be taken at the time of registration.

15.3.5 Revenue sharing structure

a) For feasible areas where BSNL bandwidth is available within 250 meters of the customer premises, Public Wi-Fi partner (PWP) shall be responsible for extending the Bandwidth connectivity from this single point to the remaining access points:

b) Revenue share to the PWP shall be at 25% of the net revenue for 1- 4 APs Plans.

c) Revenue share to the PWP shall be at 28% of the net revenue for 5- 10 APs Plans.

d) Share of revenue to the PWP shall be @ 30% of the net revenue for Plans beyond 4 APs.

e) Plan charges and applicable revenue to the PWP for 1 – 4 APs, 5 – 10 APs and 11 – 20 APs Plans is provided in the table below:

Table 1: Revenue sharing

Min. bandwidth in Mbps	Annual plan charges for 1-4 AP plans	Revenue share to PWP	Min. bandwidth in Mbps	Annual plan charges for 5-10 AP plans	Revenue share to PWP	Min. bandwidth in Mbps	Annual plan charges for 11-20 AP plans	Revenue share to PWP
10	300000	25% of the net realized revenue	NO	NO	NO	NO	NO	NO
20	350000		NO	NO	NO	NO	NO	NO
30	400000		YES	525000	25% of the net	NO	NO	NO
40	450000		YES	575000		NO	NO	NO

50	500000		YES	625000		YES	900000	30% of the net revenue
60	550000		YES	675000		YES	950000	
100	Revenue share to the PWP shall be as per the no. of AP plans, however, incremental BW charges applicable which shall be payable to BSNL only.					YES	1050000	

15.4 ESTABLISHMENT AND MAINTENANCE OF CUSTOMIZED WIDE AREA NETWORK (WAN)

BSNL is a major telecommunication service provider in India. It offers all kinds of telecommunication services like Basic (both fixed and wireless), Broadband, Internet Leased Line, Point to Point Leased Line, MPLS etc.

Keeping pace with the technological trend to provide single window enterprise solution to its customers, BSNL, Calcutta Telephones is providing complete network system solutions in building Wide Area Network on turnkey basis including supply, installation, integration and maintenance of networking equipment.

15.4.1 Objectives to be achieved by Franchisee

a) Establishment of LAN/WAN on turnkey basis including supply, installation, integration and maintenance of networking equipment.

b) Complete system integration, networking, design, implementation and management.

C) Establishment of LAN/WAN on turnkey basis including supply, installation, integration and maintenance of Video Conferencing Equipment, Public addressing System and other upcoming Corporate Office Solutions.

15.4.2 Method of Operation

a) For providing complete end-to-end solution to customer, BSNL intends to empanel System Integrators who will not only do all the operations and maintenance activities of customer end networking equipment but will also do the marketing.

b) The empanelled SIs will submit the best possible rate so as to enable BSNL to bid successfully in any tender. Based on the quotes received from various SIs, the price for each model and each make will be finalized on the lowest of the quote received. This will form the base price. On which BSNL will submit its own proposal to the customer. For providing last mile connectivity to the customer, BSNL will co-ordinate internally with all agencies /Departments to enable the same.

15.4.3 Eligibility Criteria

a) Network/System Integrator should be an IT/Networking sector company in case of National and Circle SIs. And for Circle-Silver SI it may be an individual or proprietorship/partnership concern.

b) SI or its parent company should be a public limited or private limited company registered in India in case of National and Circle SIs. Circle-Silver SI may be an Individual/

Proprietor/ partnership Concern /LLP / Company and registered as per commercial laws to undertake the activities mentioned in scope of empanelment.

c) Network/System Integrator shall be a direct owner of technology or have a direct teaming agreement with each of technology companies that form the core building block for WAN or related project implementation.

d) The Network/System Integrator should provide letters of support from Original Equipment Manufacturer (OEM) stating that their solution will be supported on the platform proposed by Network/System Integrator for the next five years.

e) The Network/ System Integrator should be ISO 9001:2008 or higher certified for services.

f) The technical team of Network/System Integrators will assist BSNL in coming out with the cost effective solution for the customers and will be required to give joint presentation with BSNL to customers.

g) Each empanelled Network/System Integrator will need to submit refundable security deposit in the form of Bank Guarantee from any scheduled bank valid for one year.

h) Network/System Integrator shall also submit additional PBG of at least 5% of the P.O. value, whenever a work is awarded to Network/System Integrator valid for the duration of the project.

i) Network/System Integrator shall provide 24X7 help centre either web-based or IVRS based. Network/System Integrator shall ensure consultation, assistance and advice within 4(four) hours or as defined in SLA entered with customer.

j) Network/System Integrator shall support SLA requirements of BSNL customers and ensure its compliance. In case SLA commitments are not met, Network/System Integrator shall be responsible for payment of penalties, if any, imposed by the customer.

k) The PBG valid for five and half years shall be collected from the empanelled SIs subject to minimum of Rs. 15 Lakhs, 3 Lakhs and Rs. 50,000/- for National level, Circle level and Circle-Silver SIs respectively for abiding by the general rules of empanelment agreement. The refundable SD of Rs. 1.0 Lakh, Rs.50,000 and Rs.10,000 respectively submitted at the time of application for empanelment would stand released thereafter.

l) Once a SI is empanelled in National Category in any of the Circle, it can get empanelled in any other Circle with a consent letter

m) NTR Circle would be treated as a Circle with its geographical territory as NCT, Delhi for the purpose of SI empanelment and delivery of service.

n) Validity of the agreement to be signed between circle and empanelled SI (in case of National, Circle and Circle-Silver level) shall be 5 (Five) years i.e. the agreement shall be signed between circle and empanelled SI for a period of 5 years.

15.5 PABX

BSNL is providing Telecommunication Services to Enterprise customer such as Government Organizations, Public Sector Undertakings, MNCs, Corporate, Hotels, Housing Societies and all other Commercially Important Customers (CIC's) through the provision of Voice & Data PABX at their premises on a rental cum usage charge basis and accordingly

seeks to empanel eligible firms / companies at National / Circle level for providing such Voice & Data PABX service on Revenue Share Basis as **PABX Franchisees of BSNL**.

15.5.1 Salient points of the Free PABX Scheme

BSNL contemplates to provide the following services to its customers under this scheme

a) Intra & Inter Office Voice Connectivity…….Essential

b) Data Connectivity & Internet Access…….Optional

c) Value Added Services (VAS)…….Optional

d) The VAS services may include services like Voice mail, audio/video conferencing, Predictive Dialers, Automatic Call Distribution, call forwarding, encrypted communication, Information Pop-Up Screens, VoIP, Voice Mail, Inter Office Video-Conferencing etc.

e) The above Telecommunication Services portfolio may be modified / supplemented to include latest services in line with the customers' preferences, market demands and in accordance with BSNL requirements, from time to time.

15.5.2 Key features of the scheme

a) The proposed agreement with the prospective firms / companies shall be entered for an initial period of five years. Any customer enrolled under the scheme during the agreement period would have to be served by the concerned franchisee for a minimum period of 3 (Three) Years or for such extended periods as agreed upon by the Customer and BSNL from the commencement of such services to the specific Customer.

b) PABX franchisee shall supply, install, operate and maintain the Voice & Data PABX on BSNL's advice.

c) BSNL shall provide all back haul voice and data connectivity to the said Voice & Data PABX.

d) The customers under the scheme shall not be charged the rentals for the junction connectivity and shall only be charged a rental on the extensions provided. Call usage and data connectivity shall be charged on applicable tariff of BSNL.

e) BSNL shall share both the rentals and the call/data usage revenue with the PABX franchisee at the applicable rates prescribed. The tariff may be modified by BSNL as per the business requirements.

f) Revenue share to the PABX Franchisee shall be made only on the revenue realized/collected.

g) The services shall be provided under the brand names of BSNL only.

h) Both BSNL and PABX Franchisee shall jointly market the scheme.

15.5.3 Eligibility Criterion

15.5.3.1 For National Level empanelment

a) Indian registered Firm / Company.

b) Shall be manufacturer / Distributer of the Voice and Data PABX Switch. In case of Distributor, must have 10 Years support agreement from OEM.

c) Shall have a minimum annual turnover of Rs.1.50 Crores during each of the last three financial years.

d) Experience of Installation / Sales & Service / Operation & Maintenance of minimum 20,000 PABX ports spread in different parts of country (Minimum 3 States) during last financial year.

e) Shall not be a Licensed Telecom Service Provider for any of the Telecom Services in India.

15.5.3.2 For Circle Level empanelment

a) Indian registered Firm / Company.

b) Shall be manufacturer / Distributer of the Voice and Data PABX Switch. In case of Distributor, must have 10 Years support agreement from OEM.

c) Shall have a minimum annual turnover of Rs.0.50 Crores during each of the last three financial years.

d) Experience of Installation / Sales & Service / Operation & Maintenance of minimum 2000 PABX ports during last financial year.

e) Shall not be a Licensed Telecom Service Provider for any of the Telecom Services in India.

15.5.4 PABX Franchisee's Role & Responsibilities

a) PABX Franchisee shall market/promote the PABX Services at its own cost under the brand name of BSNL.

b) PABX Franchisee will provide following equipment at the customer premises intimated in writing by BSNL in order to deliver the Telecommunication Services to the BSNL Customers in the Areas of Operation.

c) Hardware & Software for Voice & Data PABX as per the demand of customer.

d) FCBC, Batteries, MDF, Inter-Connect Cables (from PABX to MDF), DDF etc

e) Modems, Media Convertors etc. required for interface to PABX.

f) Customer Premise Equipment for Broadband access service viz. Router, xDSL Modems& Splitters.

g) Cabling/ Wiring at Customer Premises, if required by the customer separately chargeable.

h) PABX Franchisee shall comply with all applicable laws, byelaws, rules, regulations, orders, directions, notifications etc as per Law of the land and of Government/ court/ tribunals.

i) PABX Franchisee shall comply and enable BSNL in complying all laws related to Lawful Interception of all voice and data communication provided through the PABX system and may be asked to supply CDR/IPDR records.

15.5.5 BSNL's Role & Responsibilities

a) BSNL shall provide the required bandwidth and connectivity to its network for the PABX, subject to technical feasibility as per the applicable policies of BSNL

b) The customers garnered by the PABX Franchisees, shall be directly allocated to the respective PABX Franchisee. However, customer registering directly with BSNL, shall be allocated between the different franchisees in a round-robin manner.

c) BSNL shall raise the bills for these services utilizing its own resources and the collection of the same shall be done.

d) BSNL shall fix the tariffs applicable to customers for Telecommunication Services in different circles taking into consideration the local factors, prevailing competition, market scenario, etc. BSNL shall be free to modify these tariffs from time to time.

e) BSNL shall share the revenue earned as per the agreement between BSNL and PABX Franchisee.

f) Special business cases may however be signed by BSNL with any customer for special periods, special needs and with special conditions in consultation with the empanelled Franchisee(s) with the same or different revenue share arrangement.

15.6 NETWORK SYSTEM SOLUTION

Network System Solution is required to supply, configure, Install, Commission the networking equipments/hardware/Software at third party premise, along with integration with the existing LAN wherever applicable & Acceptance Testing of system installed. Maintenance & supply of spare parts of the equipments supplied & installed will be the integral part of the work.

Required functionality of the proposed network is as follows:

a) BSNL has provided 1 Gbps links from third party premises to NKN PoP in CTD through optical fibre. The link is terminated in the NKN router at third party premises.

b) Equipments shall be supplied at the sites as specified at the time of placement of P.O.

c) Installation, Configuration, Commissioning of LAN & wi-fi system and Integration with existing Local Area Network (LAN) at third party location as per the third party requirement shall be done by the bidder. The bidder shall be fully responsible for any damage caused by the installation of LAN & wi-fi equipment to the third party buildings and will have to repair and rectify any such damage in at his own cost before completion of the network. Restoration of faults related to equipments has to be done by the bidder.

d) Change of configuration if required due to conversion/shifting of links to be done by bidder.

15.6.1 Broad Technical Requirements:

Networking Devices:

a) Firewall with necessary accessories at third party location

- capable of supporting 1 Gbps Internet Bandwidth.

b) Core Switch with necessary accessories – capable of handling traffic to and from above firewall and interfacing with access switches.

c) Access switches with necessary accessories at third party location - capable of handling traffic between core switch & end users at third party location.

d) Wi-fi controller & access points for wireless network connectivity at third party location.

e) I/O points for LAN connectivity of end users at third party location.

f) Integration with existing LAN at third party location.

15.7 BULK SMS SOLUTION

Bulk SMS solution business is for providing Bulk SMS Services to The Financial organization. The proposal from bidder must integrate with The Financial organization's existing infrastructure seamlessly. The Current SMS volume is about 1 crore per month (which includes Domestic & International SMS) which is projected to reach 4-5 Crores SMS per month with due time. The Solution includes Real-time Push SMS Solution, Two-way SMS solution, Bulk Campaign Messaging. In addition to the above, add-on services such as Missed Call Alert Solution, Interactive SMS solution etc, needs to be provided as desired by The Financial organization.

15.7.1 Minimum Requirements from SMS System Integrator for providing Bulk SMS Solution

a) SMS solution for current & future requirement

b) Experience in SMS solution

c) Hardware, Software, Middleware & connectivity requirement

d) The System Integrator Solution should be able to establish connections simultaneously to multiple SMSC ports provided by BSNL and the solution should be able to support upto 500 TPS (Transactions per second) per port and a combined support of 2000 TPS.

e) BSNL shall provide necessary Domestic & International SMS accounts/ports at single/multiple SMSC. System Integrator should integrate the same as per the requirement of The Financial organization.

f) The System Integrator solution should have load balancing & auto-failover features in the SMS solution and should divert the SMS to other SMSC port/account in case of any failure at BSNL SMSC.

g) The System Integrators Solution should be able to identify Priority Messages received with Priority flags (eg: P1 for High Priority, P2 for Other Priority SMS, P3 for Batch SMS, P4 for Promotional SMS etc.,). Based upon the priority of the SMS, such SMSes are to be pushed to appropriate BSNL's SMSC Ports/Accounts.

h) It will be the responsibility of the System Integrator to pull the SMS from customers' servers and to push them to BSNL SMSC with an average delay of only 2 to 3 seconds in his server. The maximum delay should not exceed 5 Seconds failing which may attract penalty to the System Integrator.

i) It will be the responsibility of the System Integrator to pull the SMS from customers' servers and to push them to BSNL SMSC with an average delay of only 2 to 3 seconds in his server. The maximum delay should not exceed 5 Seconds failing which may attract penalty to the System Integrator.

j) The System Integrator will be responsible to take care of the SMPP connectivity from his Server to SMSC as well as Customer's Server. An Overall uptime of 99.95% is to be maintained failing which will attract penalty.

k) As per TCCCPR regulations, for Promotional SMS, the System Integrator should be connected to dedicated SMSC Port allotted for Promotional SMS for DND Scrubbing. First level DND Scrubbing should be done by the System Integrator before pushing the messages to Promotional SMS Port at BSNL SMSC.

l) System Integrator shall provide necessary Two-Way SMS solution for The Financial organization's requirement such as Mobile Banking, Interactive SMS etc., using the existing/new long code provided by BSNL/The Financial organization. If desired, BSNL may request the selected System Integrator to arrange long code from Other Operator at extra cost (if any).

m) Any add-on services such as Missed Call Alert, Interactive SMS solution etc., are to be provided by the System Integrator at free of cost (if required) as and when requested by The Financial organization during the contract period.

n) The System Integrator should provide 24*7*365 Off-site support. System Integrator should submit escalation matrix of the support team in their technical Proposal. As and when desired by The Financial organization/BSNL, qualified on-site engineers/managers shall be deputed at The Financial organization/BSNL premises for on-site support on temporary/regular basis.

o) System Integrator should have backend Software, Hardware and other technical team at their office to incorporate new features as requested by the customer from time to time and for bug fixing and any kind of support.

p) Necessary Back up devices are to be provided at The Financial organization's DC and minimum 1 year Back up is to be maintained. Old backup is to be handed over to the Customer.

q) System Integrator should provide integration support with all user departments of The Financial organization with respect to SMS Solution not limited to https, SMPP, file upload (various formats) and other interfaces as required by The Financial organization from time to time.

15.8 CONCLUSION

During the discussion of the chapter we have discussed the following points of Enterprise Business which is managed by Franchisee/TIP:

a. Enterprise Wi-Fi service
b. Establishment and Maintenance of Customized Wide Area Network (WAN)
c. PABX
d. Network System Solution
e. Bulk SMS solution etc.