# COMPANY DETAILS

## COMPANY PROFILE

Company Name: BSNL

Address: Regional telecom training centre, BSNL, Mysore

Tel No: 08212341000

Email address: rttcmysore@gmail.com

Website: rttcmysore.bsnl.co.in

Type of Company: Government

Founder(s): Government of India

Founded: 1 October 2000

Registered Capital: 70,746 crore

Net Income: 3,879.92 crore INR

Products/Services: Telecommunication

Number of Employees: 70,216 appx

# VISVESVARAYA TECHNOLOGICAL UNIVERSITY

# JNANASANGAMA, BELAGAVI-590018

**An Internship Report**

**ADVANCED TELECOM TECHNOLOGY**

*Submitted in partial fulfilment for the award of degree*

**Bachelor of Engineering**

**In**

**Telecommunication**

***Submitted by***

**SHUBODAYA H N**

**USN: 4VV16EC086**

*Internship Carried Out*

*At*

**Regional Telecom Training Centre, BSNL, Mysore**

*Date: 15/08/2019* *St Principal RTTC,*

*Place: Mysore* *Mysuru-570009*

## VISVESVARAYA TECHNOLOGICAL UNIVERSITY

**CENTER FOR UG STUDIES, Mysore Region, VVCE Department of ELECTRONICS AND COMMUNICATION ENGINEERING**

## DECLARATION

I, Mr. SHUBODAYA H N, bearing USN: 4VV16EC086, do hereby declare that the report entitled "BASIC TELECOM TECHNOLOGY" has been done under the guidance of Prof. Sudhakar C Gour, Professor in the Department of Telecommunication Engineering, VTU Centre for UG Studies, MYSORE, in partial fulfillment of the requirements for the award of Degree, Bachelor of Engineering in Telecommunication by Visvesvaraya Technological university, Belagavi-590018, during the academic year 2018-2019. I also declare that, to the best of my knowledge and belief, the matter embodied in this work has not been submitted previously by me for the award of any degree or to any other university.

Place: MYSORE SHUBODAYA H N

Date: USN: 4VV16EC086

# ACKNOWLEDGEMENTS

The satisfaction and euphoria that accompany the successful completion of any task would be incomplete without mentioning of the people who made it possible and under whose constant guidance and encouragement the task was completed.

I express our profound gratitude to **Prof. SUDHAKAR C GOUR** for giving us an opportunity to exhibit our talent and valuable guidance.

I take this opportunity to express my sincere thanks to our beloved internal guide. **Prof. PANI KUMAR** without whom the congenial atmosphere in which we worked have been impossible.

I would also like to thank our beloved external internship guide **Mr. Phanikumargollapalli** sir and all the teaching staff and non-teaching staff for their kind support.

My heartfelt thanks to our family members and friends whose motivation has been the backbone for successful completion of this report.

**SHUBODAYA H N**

## EXECUTIVE SUMMARY

As a part of my study, I was interested to take internship on Electronics and communications subjects. It was a great opportunity for me to do 4 weeks internship in BSNL Mysore. This is one of the Regional Telecom Training Centre of BSNL organizations. Here the internship was concentrated on the GSM systems, Optical fiber cables, switching systems and Networking.

At the beginning of the internship, I had set several learning goals regarding the improvement of knowledge and skills on telecommunication service and operation methodologies. So, I do participate in 4 communication topics during training period.

Next, I performed some tasks which were assigned by them. The major activities were Drive Test, OTDR and router configurations.

In reflection notes, I have done the assessment on myself. This internship was useful and new experience, gained knowledge and achieved many of my learning goals.

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# CHAPTER 1

# ABOUT ORGANISATION

## 1.1 INTRODUCTION

Bharat Sanchar Nigam Ltd. was incorporated on 15 September 2000. It took over the business of providing of telecom services and network management from the erstwhile Central Government Departments of Telecom Services (DTS) and Telecom Operations (DTO), with effect from 1 October 2000 on going concern basis. It is one of the largest & leading public sector units providing comprehensive range of telecom services in India.

It is the largest provider of fixed telephony and broadband services with more than 60% market share, and is the fifth largest mobile telephony provider in India. However, in recent years, the company's revenues and market share have plummeted resulting in heavy losses as a result of intense competition in the privatizing Indian telecommunications sector. BSNL is India's oldest communication service provider and had a customer base of 93.29 million as of June 2015. It has footprints throughout India, except for Mumbai and New Delhi, where Mahanagar Telephone Nigam (MTNL) manages telecommunications.

BSNL has installed Quality Telecom Network in the country & now focusing on improving it, expanding the network, introducing new telecom services with ICT applications in villages & winning customer's confidence. Today, it has about 36.42 million line basic telephone capacity, 7.13 million WLL capacity, 95.96 million GSM capacity, 34,727 fixed exchanges, 1, 17,090 GSM BTSs, 9,594 CDMA Towers, 102 Satellite Stations, 7,73,976 R Km. of OFC, 4751 R Km. of microwave network connecting 646 districts, 4519cities/towns & 6.25 lakhs villages .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. Whether it is inaccessible areas of Siachen glacier or North-Eastern regions of the country, BSNL serves its customers with a wide bouquet of telecom services namely Wireline, CDMA mobile, GSM mobile, Internet, Broadband, Carrier service, MPLS-VPN, VSAT, VoIP, IN Services, FTTH, etc. BSNL is one of major service provider in its license area. The company offers wide ranging & most transparent tariff schemes designed to suit every customer. BSNL has 94.36 million cellular &

1.02 million WLL customers as on 31.10.2016. 3G Facility has been given to all 2G connections of BSNL. In basic services, BSNL is miles ahead of its rivals, with 13.88 million wireline phone subscribers i.e. 56.96% share of the wireline subscriber base. BSNL has set up a world class multi-gigabit, multi-protocol convergent IP infrastructure that provides convergent services like voice, data & video through the same Backbone & Broadband Access Network. At present there are 21.86 million broadband customers including both wireline & wireless broadband. The company has vast experience in planning, installation, network integration & maintenance of switching & transmission networks & also has a world class ISO 9000 certified Telecom Training Institute. During the 2015-16, turnover of BSNL is around Rs. 32,919 Crores.

# 1.2 BSNL PROFILE

The foundation of Telecom Network in India was laid by the British sometime in 19th century. The history of BSNL is linked with the beginning of Telecom in India. In $19^{th}$ century and for almost entire 20th century, the Telecom in India was operated as a Government of India wing. Earlier it was part of erstwhile Post & Telegraph Department (P&T). In 1975 the Department of Telecom (DoT) was separated from P&T. DoT was responsible for running of Telecom services in entire country until 1985 when Mahanagar Telephone Nigam Limited (MTNL) was carved out of DoT to run the telecom services of Delhi and Mumbai. It is a wellknown fact that BSNL was carved out of Department of Telecom to provide level playing field to private telecoms. Subsequently in 1990s, the Government for Private investment opened up the telecom sector; therefore, it became necessary to separate the Government's policy wing from Operations wing. The Government of India corporatised the operations wing of DoT on October 01, 2000 and named it as Bharat Sanchar Nigam Limited (BSNL).BSNL operates as a public sector.

## Main Services being provided by BSNL

BSNL provides almost every telecom service, however following are the main telecom Services being provided by BSNL in India

**1. Universal Telecom Services:** Fixed wireline services & Wireless in Local loop (WLL) using CDMA Technology called bfone and Tarang respectively. BSNL is dominant operator in fixed Line. As on March 31, 2010 (end of financial year), BSNL had 76% share of fixed and WLL phones.

**2**. **Cellular Mobile Telephone Services**: BSNL is major provider of Cellular Mobile Telephone services using GSM platform under brand name Cellone. Pre-paid Cellular services of BSNL are known as Excel. As on March 31, 2010 BSNL had 17% share of mobile telephony in the country.

**3. Internet**: BSNL is providing internet as dial-up connection (Sancharnet ) and ADSLBroadband Data one. BSNL has around 50% market share in broadband in India. BSNL has planned aggressive rollout in broadband for current financial year.

**4. Intelligent Network (IN)**: BSNL is providing IN services like tele-voting,toll free calling, premium calling etc.

# 1.3 VISION AND MISSION OF BSNL

### 1.3.1 VISION OF BSNL

- Be the leading telecom service provider in India with global presence.
- Create a customer-focused organization with excellence in customer care, sales and marketing.
- Leverage technology to provide affordable and innovative telecom. Services/products across customer segments.

### 1.3.2 MISSION OF BSNL

- Becoming the most trusted, preferred and admired telecom brand
- Providing reliable telecom services that are value for money
- Generating value for all stakeholders – employees, shareholders, vendors & business associates
- Excellence in customer service -friendly, reliable, time bound, convenient and courteous service
- Offering differentiated products/services tailored to different service segments
- Developing a marketing and sales culture that is responsive to customer needs
- To explore International markets for Global presence
- Maximizing return on existing assets with sustained focus on profitability
- 8.

# 1.4 OBJECTIVE OF BSNL

- To increasing sales revenue with focus on subscriber retention & acquisition by way of strengthening sales & marketing, quality of service and customer delivery
- Accelerate the pace of expansion of mobile & data services with up-gradation of technology
- Increasing BSNL visibility in urban, sub-urban and rural areas
- Developing sales and marketing team with attitude towards customer care

- To improve customer care by reducing fault rate, upgrading Customer service Centres (CSCs) and introducing convergent billing
- Providing a conducive work environment with strong focus on performance to enhance customer delight towards BSNL services
- Leverage data services to increase BSNL's customer's base & revenues by providing higher bandwidths capabilities for wire line and wireless broadband customers
- To strengthen company's finances by gainful utilization of its assets through sharing / monetization of existing infrastructure like land, building and sharing of passive infrastructure like towers etc.
- Creating Wi-Fi Hot Spots and replacing Legacy wire line exchanges by Next Generation Network.
- Expanding the reach of fiber network near to the customer premises particularly in apartment complexes through FTTH in order to meet the ever increasing bandwidth requirement for both data & video applications
- To leverage the existing infrastructure of BSNL thereby contributing towards nation building by facilitating the execution of government programmes and initiatives viz. National Optical Fiber Network (NOFN), Network for Spectrum (NFS), and dwelling on Smart City concept
- To improve productivity by training and skill development and redeployment of legacy manpower Developing knowledge pool exposed to latest technological advancements .To explore opportunities in international telecom in developing markets
- To become preferred service provider to the Government for reliable and secure service Network and to serve National security interests

## 1.5 SERVICES AND BUSINESS

BSNL Mobile is a major provider of GSM cellular mobile services under the brand name Cell one. BSNL provides a complete telecom services solution to enterprise customers including MPLS, P2P and Internet leased lines. It provides fixed line services, landline Using CDMA technology, and its own extensive optical fiber network. BSNL provides Internet access services through dial-up connections as prepaid, Net One as Postpaid and Data One as BSNL Broadband. BSNL offers value-added services such as Free Phone Service (FPH), India Telephone Card (Prepaid card), Account Card Calling (ACC), Virtual Private Network (VPN), Televoting, Premium Rate Service (PRM) and Universal Access Number (UAN). BSNL also offers the IPTV which enables customers to watch television through the Internet and Voice and Video over Internet Protocol (VVoIP). In 2007, BSNL announced plans to provide 5 million broadband connections and secured 80% of the INR 25 billion rural telephony project of the Government of India. On 20 March 2009, BSNL launched blackberry services across India. BSNL paid Rs. 101.87 billion for 3G spectrum in 2010.As of 2011, BSNL offered coverage in over 800 cities across India. BSNL launched in 2012 a 3G wireless pocket-sized router called Winknet Mf50. BSNL 3G provides HSPA+ service with a top speed of 21.1 Mbit/s downlink and 5.76 Mbit/s uplink. After providing it for 160 years, BSNL discontinued its telegraph service on 15 July 2013. It began delivering telegrams to the public in February 1855; this service was upgraded to a webbased messaging system in 2010 and had been offered through 182 telegraph offices across India. Bharat Sanchar Nigam Limited, a Public Sector Enterprise, also provides fiber plans for the home, which are generally known as BSNL FTTH broadband service. This is the fastest broadband service provided by BSNL, offering speeds up to 100Mbit/s to home based Internet users.According to a Telecom Regulatory Authority of India Report dated 19 February 2016, at the end of 2015, BSNL's 14.54% share of the broadband market placed it 4th in market share. As a wireless provider, it ranked 6th with an 8.16% share of that market. BSNL launched linguistic email service using the DATAMAIL app in eight Indian languages. On 8 June 2017, BSNL signed a memorandum of understanding (MoU) with the Universal Service Obligation Fund (USOF) to have 25,000 Wi-Fi hotspots in rural exchanges within the next six month

## 1.6 ADANCED BROADBAND TECHNOLOGY

BSNL has a world class, multi-gigabit, multi-protocol, convergent IP infrastructure through National Internet Backbone, through which it is providing convergent services through the same backbone and broadband access network. The Broadband service is available on ADSL technology (on the same copper cable that is used for connecting telephone), on a countrywide basis.

In terms of infrastructure for broadband services NIB has put India at par with most advanced nations. The services that are supported includes:

•Always-on broadband access to the Internet for residential and business customers

•Content based services

•Internet Protocol TV (IPTV)

•Games on Demand

•Music and Video on Demand

# 1.7 GROWTH PLAN

Anupam Shrivastava, chairman and managing director of Bharat Sanchar Nigam (BSNL), said the Indian telecom operator aims to focus on gaining subscriber market share and accelerate the growing enterprise business to protect revenue. BSNL's future plan include a fast expansion programme of increasing the present 34 million lines to twice that number by 2005 and to some 120 million lines by 2010. Consolidation of the network and maintaining high quality of service comparable to international standards is the key aim of the growth plan.

- Phase VII GSM expansion project of 15 million line is rolled out with further augmentation planned under Phase VII+ project.
- GSM expansion project under name Phase VIII.4 has been initiated for the following:
- Replacement of old equipment having high operational cost & AMC.
- Addition of 3G capacity for increasing 3G footprints.
- Introduction of 4G services. Migration of Wireline customers from legacy Network to Next Generation Network (NGN).
- Roll out of Wi-Fi service: BSNL has planned to install 40,000 Hotspots in the coming years.
- Augmentation of Optical Fiber network.
- Executing DoT's work of building alternate communication infrastructure for Defence (NFS).
- Executing BBNL's part work/project of high Speed Broadband connectivity to Panchayat(NOFN).
- Installation of Mobile Towers in Left Wing Extremism (LWE) areas.
- Implementation of Comprehensive Transmission-Development Plan for North Eastern Region to cover over 3200 Kms via OFC.

# CHAPTER 2

# ABOUT RTTC

## 2.1 RTTC PROFILE

The Regional Telecom Training Centre (RTTC), Mysore is one of the pioneer Telecom

Training Centers in India serving for the training needs on different fields of Telecommunication, Accounts, Computers, Civil, Electrical, Management and Information Technology for the officers/Staff of e Bharat Sanchar Nigam Limited, India. Offers training in telecom technology to reputed IT companies such as Infosys, Cable and Wireless, Nano Cell and Engineering students. RTTC is also committed to establishing a QMS conforming to the requirements of ISO 9001:2008 certified Centre of excellence is equipped with state of the art telecom technology laboratories.

RTTC, Mysore has been recognized as the "Centre for excellence in Computers" by the Telecom directorate as a result of its excellent infrastructure in the field of Computers.

Engineering colleges, technical institutions are welcome for training in latest Telecom Technologies

The centre has been identified as “Centre for excellence in computer” by DOT in the year 1998.RTTC Mysore was identified as one of the favour training Centre in BSNL to impart specialized training on GSM for newly inducted JTO’s and in service course for other executives. Faculty members of imparting training in switching. Transmission, new telecom technologies. Marketing and sales promotion to new recruiters and departmental promotes.

RTTC is also organizing many FTP’s in varies SSAs of Karnataka circle in new technology and value added services by deputing faculty members to respective SSAs. Any Central Govt/State Govt or private firms who are interested in getting their staff trained in office automation are welcome.

TRAININGS AVAILABLE:-

1. Data Communications
2. Optical Communications
3. Wireless Communications (GSM & CDMA)
4. Digital Switching

## 2.2 STRUCTURE OF RTTC

- INFOSYS
- WIPRO
- TELEMEN
- METRO RAIL
- POSTAL DEPARTMENT
- KL UNIVERSITY
- SJCE
- NIE
- MYSORE UNIVERSITY
- NIELSEN
- KTK.STATE GOVT
- EDU.DEPT
- AYUSH DEPT
- MAHILA SAMAKHYA
- SIET PUTTUR ENG.COLLEGE,AP
- ACCENTURE ➢ SVIT BANGALORE

## Accommodation

**Fig 2.1: Switching Lab** **fig 2.2: Exam Hall**

## Administrative Block

The RTTC Mysore has an administrative / technical building of 10,400 sq.mtrs. in area, where all its administrative offices, class rooms and laboratories are located. There are 3 faculties i.e. Switching, Transmission, Computer supported by programming and administrative sections. Each faculty is presently headed by a Divisional Engineer. There are 21 class rooms for handling lecture sessions of which 14 are fully equipped with table, chair, white boards, overhead projectors, etc. There are seven High-tech class rooms with multimedia computer and LCD projectors

A wide variety of Telecommunication equipment are installed in the training Centre required for covering most of the topics of induction and refresher courses. The equipment installed are

CDOT 256 port, CDOT SBM, SBM MBM, Broad Band, MLLN, SDH and etc,. Four well equipped computer labs with a wide variety of software. Microwave systems of 2 GC 13 GC, 34 MB and 140 MB OFC systems, ISDN, SDH, GSM etc..,

The examination hall is big enough to accommodate 120 trainees at a time with individual furnitures and other facilities. The auditorium room is equally big in size to accommodate an audience of more than 300, with a stage arrangement including audiovisual facilities to conduct various cultural / official functions


**Fig 2.3: Inspection Quarters**

## 2.3 VISION AND MISSION OF RTTC

### 2.3.1 VISION OF RTTC

RTTC aspires to be one of the best telecom training Centre in India by being responsive and participant Centered Institution dedicated to academic excellence, enabling participant to think critically. Work creatively. Communicate effectively and become technological competent so as to make BSNL a vibrant company.

### **2.3.2** MISSION OF RTTC

- RTTC aperies' to deliver quality training to the best of participant's satisfaction.
- To deliver as excellence in performance of BSNL through trained and knowledgeable manpower.

## 2.4 OBJECTIVES OF RTTC

- Practical hands on exposure on the high and telecom operational equipment system to enable students for higher order domain industry exposer through face to face contact sessions.
- **Personal Development:** during internship made special effort to observe the personal style of supervisors and colleagues. Be able to identify clear examples of leadership style that either promote good working relationship or hinder to productive work environment. Note how to deal with pressure, tension, and praise in work relationships.
- To strengthen professional skills and interpersonal relationship in professional settings.
- To understand how to communicate knowledge to stranger supervisors, and subordinates. Be aware of the when to speak and when to listen. To gain practical knowledge about the organization.

# CHAPTER 3

## TASK PERFORMED

## 3.1 OPTICAL FIBER

An optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair. Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than electrical cables. Fibers are used instead of metal wires because signals travel along them with less loss; in addition, fibers are immune to electromagnetic interference, a problem from which metal wires suffer excessively. Fibers are also used for illumination and imaging, and are often wrapped in bundles so they may be used to carry light into, or images out of confined spaces, as in the case of a fiberscope. Specially designed fibers are also used for a variety of other applications, some of them being fiber optic sensors and fiber lasers.

Optical fibers typically include a core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by the phenomenon of total internal reflection which causes the fiber to act as a waveguide.[5] Fibers that support many propagation paths or transverse modes are called multi-mode fibers, while those that support a single mode are called single-mode fibers (SMF). Multi-mode fibers generally have a wider core diameter and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 1,000 meters (3,300 ft).

Being able to join optical fibers with low loss is important in fiber optic communication. This is more complex than joining electrical wire or cable and involves careful cleaving of the fibers, precise alignment of the fiber cores, and the coupling of these aligned cores. For applications that demand a permanent connection a fusion splice is common. In this technique, an electric arc is used to melt the ends of the fibers together. Another common technique is a mechanical splice, where the ends of the fibers are held in contact by mechanical force. Temporary or semi-permanent connections are made by means of specialized optical fiber connectors.

The field of applied science and engineering concerned with the design and application of optical fibers is known as fiber optics. The term was coined by Indian-American physicist Narinder Singh Kapany, who is widely acknowledged as the father of fiber optics.

Fig 3.1. A bundle of optical fibers

Fig 3.2. Fiber crew installing a 432-count fiber cable underneath the streets of Midtown Manhattan, New York City

Fig 3.3 . A TOSLINK fibre optic audio cable with red light being shone in one end transmits the light to the other end

Fig 3.4. A wall-mount cabinet containing optical fiber interconnects. The yellow cables are single mode fibers; the orange and aqua cables are multi-mode fibers: 50/125 µm OM2 and 50/125 µm OM3 fibers respectively.

Optical fiber is used as a medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with much lower attenuation compared to electrical cables. This allows long distances to be spanned with few repeaters.

The per-channel light signals propagating in the fiber have been modulated at rates as high as 111 gigabits per second (Gbit/s) by NTT, although 10 or 40 Gbit/s is typical in deployed systems. In June 2013, researchers demonstrated transmission of 400 Gbit/s over a single channel using 4-mode orbital angular momentum multiplexing.

Each fiber can carry many independent channels, each using a different wavelength of light (wavelength-division multiplexing (WDM)). The net data rate (data rate without overhead bytes) per fiber is the per-channel data rate reduced by the FEC overhead, multiplied by the number of channels (usually up to 80 in commercial dense WDM systems as of 2008). As of 2011 the record for bandwidth on a single core was 101 Tbit/s (370 channels at 273 Gbit/s each).] The record for a multi-core fiber as of January 2013 was 1.05 Pbit/s. In 2009, Bell Labs broke the 100 (Pbit/s)·km barrier (15.5 Tbit/s over a single 7000 km fiber)

## Advantages over copper wiring

The advantages of optical fiber communication with respect to copper wire systems are:

- High bandwidth
  A single optical fiber can carry over 3,000,000 full-duplex voice calls or 90,000 TV channels.
- Immunity to electromagnetic interference

Light transmission through optical fibers is unaffected by other electromagnetic radiation nearby. The optical fiber is electrically non-conductive, so it does not act as an antenna to pick up electromagnetic signals. Information traveling inside the optical fiber is immune to electromagnetic interference, even electromagnetic pulses generated by nuclear devices.

- Low attenuation loss over long distances

  Attenuation loss can be as low as 0.2 dB/km in optical fiber cables, allowing transmission over long distances without the need for repeaters.
- Electrical insulator

  Optical fibers do not conduct electricity, preventing problems with ground loops and conduction of lightning. Optical fibers can be strung on poles alongside high voltage power cables.
- Material cost and theft prevention

  Conventional cable systems use large amounts of copper. Global copper prices experienced a boom in the 2000s, and copper has been a target of metal theft.
- Security of information passed down the cable

  Copper can be tapped with very little chance of detection.

Fibers have many uses in remote sensing. In some applications, the sensor is itself an optical fiber. In other cases, fiber is used to connect a non-fiberoptic sensor to a measurement system. Depending on the application, fiber may be used because of its small size, or the fact that no electrical power is needed at the remote location, or because many sensors can be multiplexed along the length of a fiber by using different wavelengths of light for each sensor, or by sensing the time delay as light passes along the fiber through each sensor. Time delay can be determined using a device such as an *optical time-domain reflectometer*.

## 3.1.1 Index of refraction

The index of refraction (or refractive index) is a way of measuring the speed of light in a material. Light travels fastest in a vacuum, such as in outer space. The speed of light in a vacuum is about 300,000 kilometers (186,000 miles) per second. The refractive index of a medium is calculated by dividing the speed of light in a vacuum by the speed of light in that medium. The refractive index of a vacuum is therefore 1, by definition. A typical singlemode fiber used for telecommunications has a cladding made of pure silica, with an index of 1.444 at 1500 nm, and a core of doped silica with an index around 1.4475.[47] The larger the index of refraction, the slower light travels in that medium. From this information, a simple rule of thumb is that a signal using optical fiber for communication will travel at around 200,000 kilometers per second. To put it another way, the signal will take 5 milliseconds to travel 1,000 kilometers in fiber. Thus a phone call carried by fiber between Sydney and New York, a 16,000-kilometer distance, means that there is a minimum delay of 80 milliseconds (about of a second) between when one caller speaks and the other hears. (The fiber in this case will probably travel a longer route, and there will be additional delays due to communication equipment switching and the process of encoding and decoding the voice onto the fiber).

Most modern optical fiber is *weakly guiding*, meaning that the difference in refractive index between the core and the cladding is very small (typically less than 1%).

Total internal reflection

When light traveling in an optically dense medium hits a boundary at a steep angle (larger than the critical angle for the boundary), the light is completely reflected. This is called total internal reflection. This effect is used in optical fibers to confine light in the core. Light travels through the fiber core, bouncing back and forth off the boundary between the core and cladding. Because the light must strike the boundary with an angle greater than the critical angle, only light that enters the fiber within a certain range of angles can travel down the fiber without leaking out. This range of angles is called the acceptance cone of the fiber. The size of this acceptance cone is a function of the refractive index difference between the fiber's core and cladding.

In simpler terms, there is a maximum angle from the fiber axis at which light may enter the fiber so that it will propagate, or travel, in the core of the fiber. The sine of this maximum angle is the numerical aperture (NA) of the fiber. Fiber with a larger NA requires less precision to splice and work with than fiber with a smaller NA. Single-mode fiber has a small NA.

Multi-mode fiber

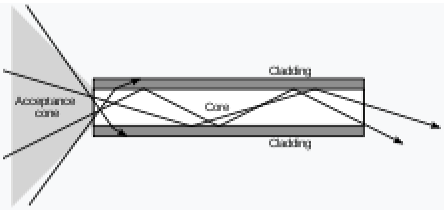


Fig 3.5. The propagation of light through a multi-mode optical fiber.

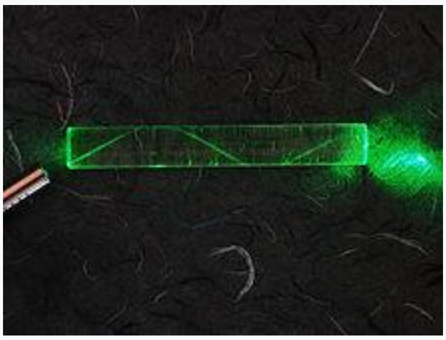

Fig 3.6. A laser bouncing down an acrylicrod, illustrating the total internal reflection of light in a multi-mode optical fiber.

### 3.1.2 Multi-mode optical fiber

Fiber with large core diameter (greater than 10 micrometers) may be analyzed by geometrical optics. Such fiber is called *multi-mode fiber*, from the electromagnetic analysis (see below). In a step-index multi-mode fiber, rays of light are guided along the fiber core by total internal reflection. Rays that meet the core-cladding boundary at a high angle (measured relative to a line normal to the boundary), greater than the critical angle for this boundary, are completely reflected. The critical angle (minimum angle for total internal reflection) is determined by the difference in index of refraction between the core and cladding materials. Rays that meet the boundary at a low angle are refracted from the core into the cladding, and do not convey light and hence information along the fiber. The critical angle determines the acceptance angle of the fiber, often reported as a numerical aperture. A high numerical aperture allows light to propagate down the fiber in rays both close to the axis and at various angles, allowing efficient coupling of light into the fiber. However, this high numerical aperture increases the amount of dispersion as rays at different angles have different path lengths and therefore take different times to traverse the fiber.

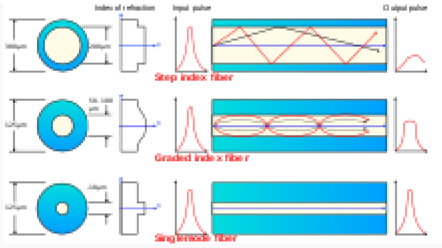


Fig 3.7. Multimode optical fiber

In graded-index fiber, the index of refraction in the core decreases continuously between the axis and the cladding. This causes light rays to bend smoothly as they approach the cladding, rather than reflecting abruptly from the core-cladding boundary. The resulting curved paths reduce multi-path dispersion because high angle rays pass more through the lower-index periphery of the core, rather than the high-index center. The index profile is chosen to minimize the difference in axial propagation speeds of the various rays in the fiber. This ideal index profile is very close to a parabolic relationship between the index and the distance from the axis.

### 3.1.3 Single-mode fiber

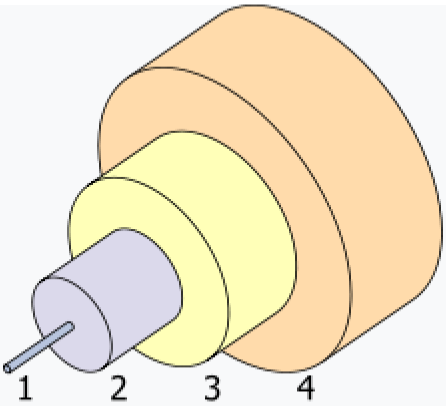


Fig 3.8. Single-mode optical fiber

The structure of a typical single-mode fiber.

1. Core: 8 µm diameter
2. Cladding: 125 µm dia.
3. Buffer: 250 µm dia.
4. Jacket: 400 µm dia.

Fiber with a core diameter less than about ten times the wavelength of the propagating light cannot be modeled using geometric optics. Instead, it must be analyzed as an electromagnetic structure, by solution of Maxwell's equations as reduced to the electromagnetic wave equation. The electromagnetic analysis may also be required to understand behaviors such as speckle that occur when coherent light propagates in multi-mode fiber. As an optical waveguide, the fiber supports one or more confined transverse modes by which light can propagate along the fiber. Fiber supporting only one mode is called *single-mode* or *mono-mode fiber*. The behavior of larger-core multi-mode fiber can also be modeled using the wave equation, which shows that such fiber supports more than one mode of propagation (hence the name). The results of such modeling of multi-mode fiber approximately agree with the predictions of geometric optics, if the fiber core is large enough to support more than a few modes.

The waveguide analysis shows that the light energy in the fiber is not completely confined in the core. Instead, especially in single-mode fibers, a significant fraction of the energy in the bound mode travels in the cladding as an evanescent wave.

The most common type of single-mode fiber has a core diameter of 8–10 micrometers and is designed for use in the near infrared. The mode structure depends on the wavelength of the light used, so that this fiber actually supports a small number of additional modes at visible wavelengths. Multi-mode fiber, by comparison, is manufactured with core diameters as small as 50 micrometers and as large as hundreds of micrometers.

The normalized frequency $V$for this fiber should be less than the first zero of the Bessel function $J_0$ (approximately 2.405).

## Special-purpose fiber

Some special-purpose optical fiber is constructed with a non-cylindrical core and/or cladding layer, usually with an elliptical or rectangular cross-section. These include polarization-maintaining fiber and fiber designed to suppress whispering gallery mode propagation. Polarization-maintaining fiber is a unique type of fiber that is commonly used in fiber optic sensors due to its ability to maintain the polarization of the light inserted into it.

Photonic-crystal fiber is made with a regular pattern of index variation (often in the form of cylindrical holes that run along the length of the fiber). Such fiber uses diffraction effects instead of or in addition to total internal reflection, to confine light to the fiber's core. The properties of the fiber can be tailored to a wide variety of applications.

### 3.1.4 Cable construction

Fig 3.9. An optical fiber cable

In practical fibers, the cladding is usually coated with a tough resin coating and an additional *buffer* layer, which may be further surrounded by a *jacket* layer, usually plastic. These layers add strength to the fiber but do not contribute to its optical wave guide properties. Rigid fiber assemblies sometimes put light-absorbing ("dark") glass between the fibers, to prevent light that leaks out of one fiber from entering another. This reduces cross-talk between the fibers, or reduces flare in fiber bundle imaging applications.

Modern cables come in a wide variety of sheathings and armor, designed for applications such as direct burial in trenches, high voltage isolation, dual use as power lines, installation in conduit, lashing to aerial telephone poles, submarine installation, and insertion in paved streets. Multi-fiber cable usually uses colored coatings and/or buffers to identify each strand. The cost of small fiber-count pole-mounted cables has greatly decreased due to the high demand for fiber to the home (FTTH) installations in Japan and South Korea.

Fiber cable can be very flexible, but traditional fiber's loss increases greatly if the fiber is bent with a radius smaller than around 30 mm. This creates a problem when the cable is bent around corners or wound around a spool, making FTTX installations more complicated. "Bendable fibers", targeted towards easier installation in home environments, have been standardized as ITU-T G.657. This type of fiber can be bent with a radius as low as 7.5 mm without adverse impact. Even more bendable fibers have been developed. Bendable fiber may also be resistant to fiber hacking, in which the signal in a fiber is surreptitiously monitored by bending the fiber and detecting the leakage.

Another important feature of cable is cable's ability to withstand horizontally applied force. It is technically called max tensile strength defining how much force can be applied to the cable during the installation period.

Some fiber optic cable versions are reinforced with aramid yarns or glass yarns as intermediary strength member. In commercial terms, usage of the glass yarns are more cost effective while no loss in mechanical durability of the cable. Glass yarns also protect the cable core against rodents and termites.

## Fiber fuse

At high optical intensities, above 2 megawatts per square centimeter, when a fiber is subjected to a shock or is otherwise suddenly damaged, a *fiber fuse* can occur. The reflection from the damage vaporizes the fiber immediately before the break, and this new defect remains reflective so that the damage propagates back toward the transmitter at 1–3 meters per second (4–11 km/h, 2–8 mph).The open fiber control system, which ensures laser eye safety in the event of a broken fiber, can also effectively halt propagation of the fiber fuse.[78] In situations, such as undersea cables, where high power levels might be used without the need for open fiber control, a "fiber fuse" protection device at the transmitter can break the circuit to keep damage to a minimum.

## Free-space coupling

It is often necessary to align an optical fiber with another optical fiber, or with an optoelectronic device such as a light-emitting diode, a laser diode, or a modulator. This can involve either carefully aligning the fiber and placing it in contact with the device, or can use a lens to allow coupling over an air gap. Typically the size of the fiber mode is much larger than the size of the mode in a laser diode or a silicon optical chip. In this case, a tapered or lensed fiber is used to match the fiber mode field distribution to that of the other element. The lens on the end of the fiber can be formed using polishing, laser cutting or fusion splicing.

## Fiber Colour Codes

Inside the cable or inside each tube in a loose tube cable, individual fibers will be color coded for identification. Fibers follow the convention created for telephone wires except fibers are identified individually, not in pairs. For splicing, like color fibers are spliced to ensure continuity of color codes throughout a cable run.

| Fiber Number | Color |
|---|---|
| 1 | Blue |
| 2 | Orange |
| 3 | Green |

| | |
|---|---|
| 4 | Brown |
| 5 | Slate |
| 6 | White |
| 7 | Red |
| 8 | Black |
| 9 | Yellow |
| 10 | Violet |
| 11 | Rose |
| 12 | Aqua |

Table 3.1 Fiber color number

| Fiber Type | Color Code | | |
|---|---|---|---|
| . | Non-military Applications(3) | Military Applications | Suggested Print Nomenclature |
| Multimode (50/125) (OM2) | Orange | Orange | OM2, 50/125 |
| Multimode (50/125) (850 nm Laser-optimized) (OM3, OM4) | Aqua | Undefined | OM3 or OM4, 850 LO 50 /125 |
| Multimode (50/125) (850 nm Laser-optimized) (OM5) | Lime Green | | OM5 |
| Multimode (62.5/125) (OM1) | Orange | Slate | OM1, 62.5/125 |
| Multimode (100/140) | Orange | Green | 100/140 |
| Single-mode (OS1, OS1a, OS2) | Yellow | Yellow | OS1, OS1a, OS2, SM/NZDS, SM |
| Polarization Maintaining Single-mode | Blue | Undefined | Undefined (2) |

Table 3.2 Fiber type color code

### 3.1.5 Connector Colour Codes:

Since the earliest days of fiber optics, orange, black or gray was multimode and yellow single mode. However, the advent of metallic connectors like the FC and ST made connector color coding difficult, so colored strain relief boots were often used.

| Fiber type | Connector Body | Strain<br>Mating Adapter |
|---|---|---|
| 62.5/125 | Beige | Beige |
| 50/125 | Black | Black |
| 50/125 laser optimized | Aqua | Aqua |
| OM5 | Lime | Lime |
| Singlemode | Blue | Blue |
| Singlemode APC | Green | Green |

Table 3.3 Connector color codes

### 3.1.6 Plesiochronous digital hierarchy

The plesiochronous digital hierarchy (PDH) is a technology used in telecommunications networks to transport large quantities of data over digital transport equipment such as fibre optic and microwave radio systems.[1] The term *plesiochronous* is derived from Greek *plēsios*, meaning near, and *chronos*, time, and refers to the fact that PDH networks run in a state where different parts of the network are nearly, but not quite perfectly, synchronized.

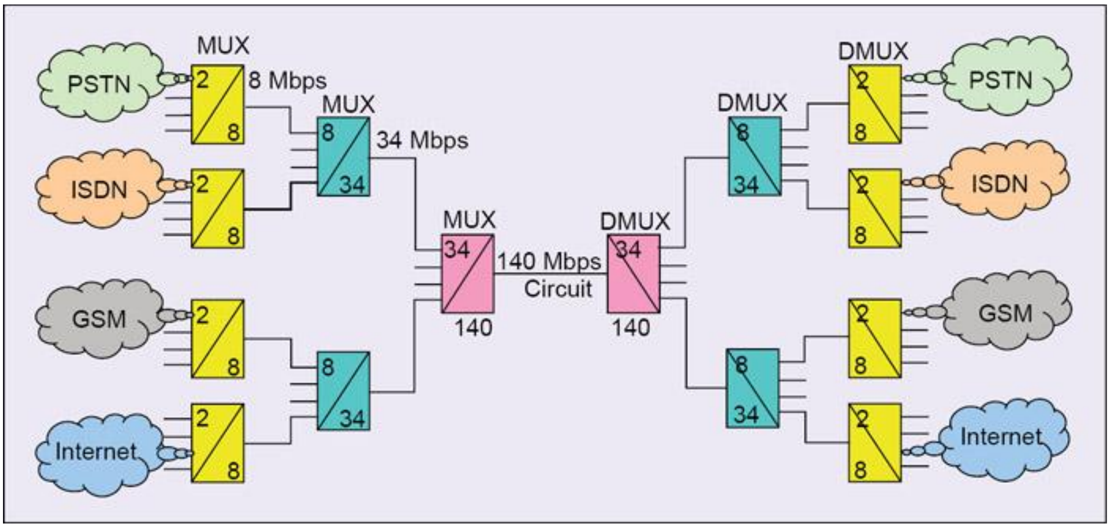


Fig 3.10 Plesiochronous digital hierarchy

### 3.1.7 STM-1

The STM-1 (Synchronous Transport Module level-1) is the SDH ITU-T fiber optic network transmission standard. It has a bit rate of 155.52 Mbit/s. Higher levels go up by a factor of 4 at a time: the other currently supported levels are STM-4, STM-16, STM-64 and STM-256. Above STM-256 wavelength-division multiplexing (WDM) is commonly used in submarine cabling.

#### Frame structure

The STM-1 frame is on the basic transmission format for SDH (Synchronous Digital Hierarchy). A STM-1 frame has a byte-oriented structure with 9 rows and 270 columns of bytes, for a total of 2,430 bytes (9 rows * 270 columns = 2430 bytes). Each byte corresponds to a 64kbit/s channel.[3]

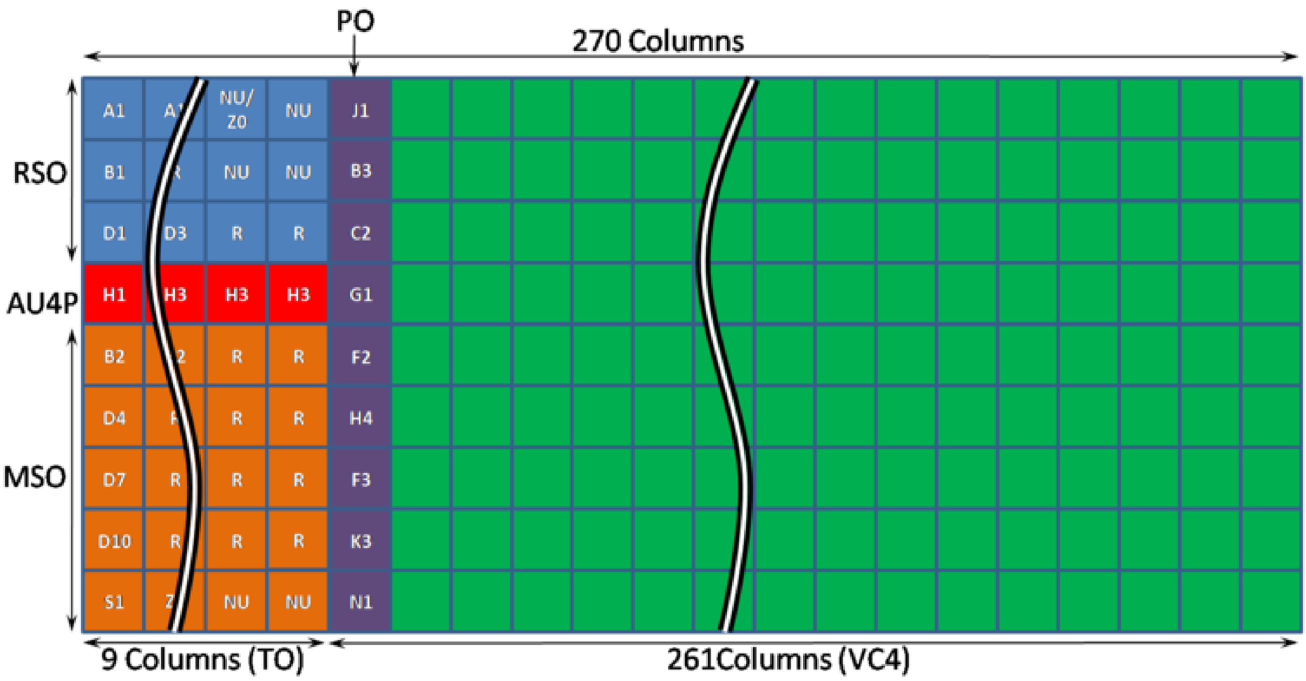


Fig 3.11 Frame structure

TOH: Transport Overhead (RSOH + AU4P + MSOH)

- MSOH: Multiplex Section Overhead
- RSOH: Regeneration Section Overhead
- AU4P: AU-4 Pointers

VC4: Virtual Container-4 payload (POH + VC-4 Data)

- POH: Path Overhead

## Frame characteristic

The STM-1 base frame is structured with the following characteristics:

- Length: 270 column × 9 row = 2430 bytes
- Byte: 1-byte = 8 bit
- Duration (Frame repetition time): 125 µs i.e. 8000 frame/s
- Rate (Frame capacity): 2430 × 8 × 8000 = 155.5200 Mbit/s
- Payload = 2349bytes × 8bits × 8000frames/sec = 150.336 Mbit/s

## Fiber to the *x*

- *FTTB, FTTC, FTTD, FTTH, FTTK, FTTN, and FTTP all redirect here. For airports with those ICAO codes, see List of airports in Chad.*

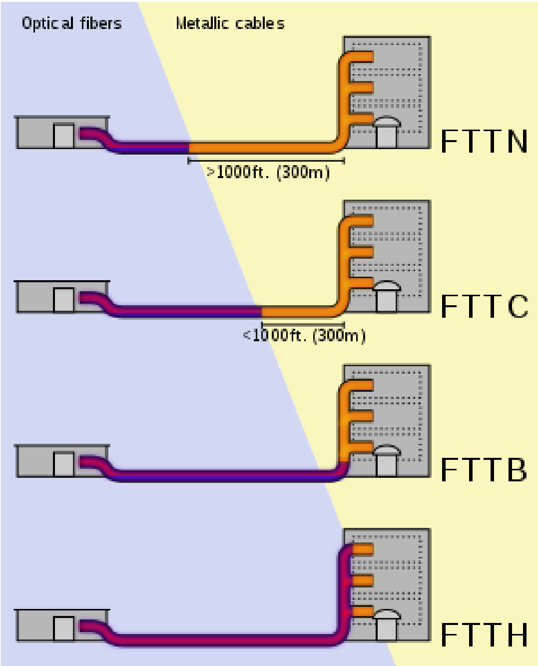


Fig 3.12 Fiber x

- A schematic illustrating how FTTX architectures vary with regard to the distance between the optical fiber and the end user. The building on the left is the central office; the building on the right is one of the buildings served by the central office. Dotted rectangles represent separate living or office spaces within the same building.

## Definitions

The telecommunications industry differentiates between several distinct FTTX configurations. The terms in most widespread use today are:

- FTTP (fiber-to-the-premises): This term is used either as a blanket term for both FTTH and FTTB, or where the fiber network includes both homes and small businesses
- FTTH (fiber-to-the-home): Fiber reaches the boundary of the living space, such as a box on the outside wall of a home. Passive optical networks and point-to-point Ethernet are architectures that are capable of delivering triple-play services over FTTH networks directly from an operator's central office.[2][3]

- FTTB (fiber-to-the-building, -business, or -basement): Fiber reaches the boundary of the building, such as the basement in a multi-dwelling unit, with the final connection to the individual living space being made via alternative means, similar to the curb or pole technologies
- FTTD (fiber-to-the-desktop): Fiber connection is installed from the main computer room to a terminal or fiber media converter near the user's desk
- FTTR (fiber-to-the-router): Fiber connection is installed from the router to the ISP's fiber network
- FTTO (fiber-to-the-office): Fiber connection is installed from the main computer room/core switch to a special mini-switch (called FTTO Switch) located at the user's workstation or service points. This mini-switch provides Ethernet services to end user devices via standard twisted pair patch cords. The switches are located decentrally all over the building, but managed from one central point
- FTTF (fiber-to-the-frontage): This is very similar to FTTB. In a fiber to the front yard scenario, each fiber node serves a single subscriber. This allows for multi-gigabit speeds using XG-fast technology. The fiber node may be reverse-powered by the subscriber modem[4]
- FTTE / FTTZ (fiber-to-the-telecom-enclosure or fiber-to-the-zone): is a form of structured cabling typically used in enterprise local area networks, where fiber is used to link the main computer equipment room to an enclosure close to the desk or workstation. FTTE and FTTZ are not considered part of the FTTX group of technologies, despite the similarity in name.[5]
- FTTdp (Fiber To The Distribution Point): This is very similar to FTTC / FTTN but is one-step closer again moving the end of the fiber to within meters of the boundary of the customers premises in last junction possible junction box known as the "distribution point" this allows for near-gigabit speeds[6]
- FTTN / FTTLA (fiber-to-the-node, -neighborhood, or -last-amplifier): Fiber is terminated in a street cabinet, possibly miles away from the customer premises, with the final connections being copper. FTTN is often an interim step toward full FTTH (fiber-to-the-home) and is typically used to deliver 'advanced' triple-play telecommunications services
- FTTC / FTTK (fiber-to-the-curb/kerb, -closet, or -cabinet): This is very similar to FTTN, but the street cabinet or pole is closer to the user's premises, typically within 1,000 feet (300 m), within range for high-bandwidth copper technologies such as wired ethernet or IEEE 1901 power line networking and wireless Wi-Fi technology. FTTC is occasionally ambiguously called FTTP (fiber-to-the-pole), leading to confusion with the distinct fiber-to-the-premises system

### 3.1.8 TUG3-TUG2-TU12 Tributary Channel Numbering

There are several 63 E1 mappings into and from an STM-1 signal. The STM-1 Mux supports all possibilities, including Motorola, Huawei, and Lucent.

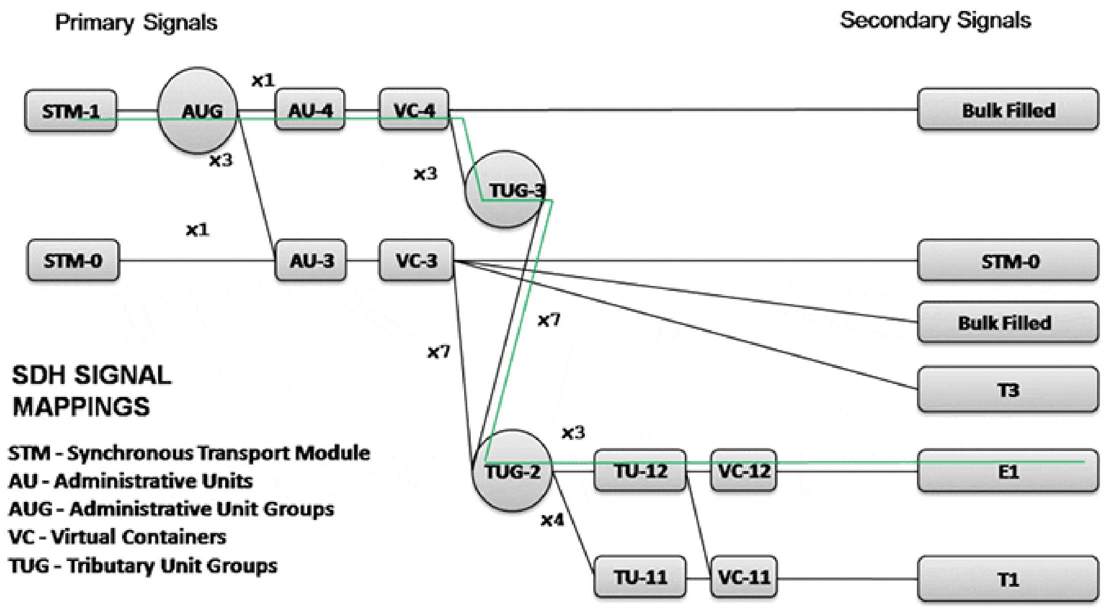


Fig 3.13 TUG3-TUG2-TU12 Tributary Channel Numbering

Technical Specifications

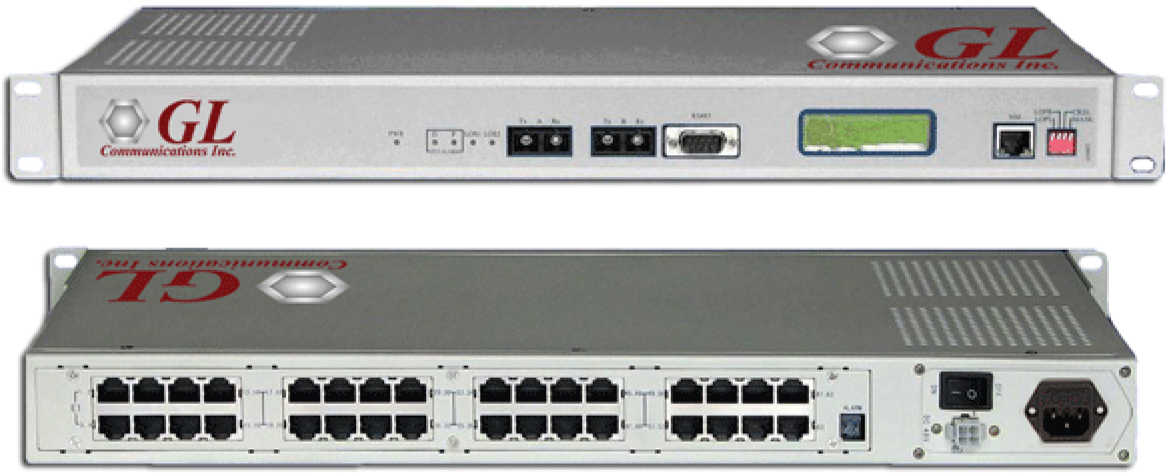

Fig 3.14 STM-1 Mux Equipment

Table 3.4 STM-1 Fiber Optic Port

| SDH Interface | |
|---|---|
| Max | 1 or 2 STM-1 optical interfaces (1+1 protection supported) |
| Bit Rate: | 155.520 Mbit/s±4.6 ppm |
| Line Code: | Scrambled NRZ |
| Protection: | Unidirectional 1+1 APS, revertive / non-revertive selectable |
| Wavelength: | Default:1310 nm nominal<br>Option /5:1550 nm nominal |
| Output Power: | Default: Min. –12 dBm<br>Option /L: Min. -5 dBm<br>Option /S: Min. –14 dBm<br>Option /SL: Min. -5 dBm |
| Sensitivity: | Default:-36 dBm<br>Option /S:-30 dBm |
| Max Input Power: | -3 dBm |
| Connector: | Default:SC<br>Option /F: FC<br>Option /S: SC |
| Spec | S-1.1, L-1.1, L-1.2<br>Single fiber bi-directional interface can be optionally supported |
| Clock Source | Internal, STM-1 Line, External, Tributaries |

Table 3.5

| PDH interface E1 Port | |
|---|---|
| Bit Rate | 2.048 Mbps ±50 ppm |
| Line Code | HDB3 |
| Impedance: | 75Ω coax/120Ω twisted pair |
| Framing | Unframed |
| Connector | RJ-48 (special wiring for two E1s) |
| Total Channels | 63 E1s |

Table 3.6

| Management Port | |
|---|---|
| Interfaces | 10Base-T and RS-485 |
| Ethernet: | RJ-45, 10Base-T adopts MDI port |
| RS-485 | Four-line RS-485, default baud rate 2400 (1200, 2400, 4800, 9600, 19200, 38400 selectable), data bit: 8; stop bit: 1; parity: odd; TABS protocol Asynchronous RS-485 data |
| Protocol | SNMP or Q3 |

Table 3.7

| Physical/Electrical | |
|---|---|
| Dimensions | 44 mm x 230 mm x 440 mm (H/D/W) 1U: 440 * 44 *230 (mm) |

| | |
|---|---|
| Net weight | 3 kg |
| Power (AC) (63 E1 over STM-1 multiplexer only): | 100 to 240 V 50/60Hz |
| Power (DC) | -48 V (-58 V to -38 V) or 220 V (110 V) AC or dual power supply +24V DC |
| Power consumption | </= 15 Watts |
| Redundancy (63 E1 over STM-1 MultiplexerRP only): | Dual -48 V DC inputs, dual internal power conversion modules |
| Temperature | 0 to 50° C |
| Humidity | 0-95% RH (non-condensing) |
| LAN port | RJ-45 |
| RS-485 port | DB-9 |
| E1 interface connector | RJ-45 |
| Optical Interface connector | FC or SC |
| Number of Optical STM-1 Ports | 1 or 2 (second for protection) |
| Number of E1 channels | 63 |
| LCD Display | Supported |

Table 3.7

| Standards Compliance |
|---|
| G.703, G.707, G.781, G.783, G.784, G.798, G.803, G.811, G.813, G.823, G.825, G.826, G.841, G.957 |

# 3.2 Digital switching system

The switching scheme used by the electronic switching systems may be either Space Division Switching or Time Division Switching. In space division switching, a dedicated path is established between the calling and the called subscribers for the entire duration of the call. In time division switching, sampled values of speech signals are transferred at fixed intervals.

The time division switching may be analog or digital. In analog switching, the sampled voltage levels are transmitted as they are whereas in binary switching, they are binary coded and transmitted. If the coded values are transferred during the same time interval from input to output, the technique is called Space Switching. If the values are stored and transferred to the output at a late time interval, the technique is called as Time Switching. A time division digital switch may also be designed by using a combination of space and time switching techniques.

## 3.2.1 Space Division Switching

The paths in a circuit are separated from each other, spatially in space division switching. Though initially designed for analog networks, it is being used for both analog and digital switching. A Crosspoint switch is mostly referred to as a space division switch because it moves a bit stream from one circuit or bus to another.

Advantages of Space Division Switching

Following is the advantage of Space Division Switching −

- It is instantaneous.

Disadvantages of Space Division Switching

- Number of Cross points required to make space-division switching are acceptable in terms of blocking.

## 3.2.2 Time Division Switching

Time division switching comes under digital switching techniques, where the Pulse Code Modulated signals are mostly present at the input and the output ports. A digital Switching system is one, where the inputs of any PCM highway can be connected to the outputs of any PCM highway, to establish a call. The incoming and outgoing signals when received and re-transmitted in a different time slot, is called Time Division Switching. The digitized speech information is sliced into a sequence of time intervals or slots. Additional voice circuit slots, corresponding to other users are inserted into this bit stream of data. Hence, the data is sent in time frames.

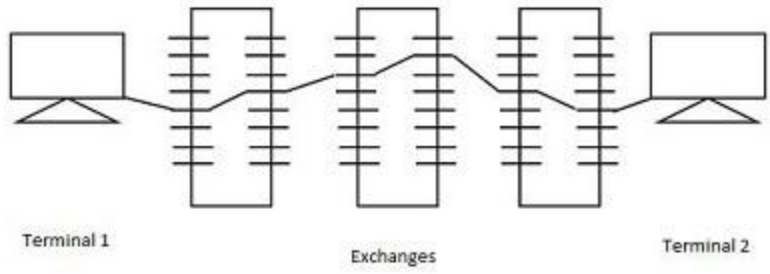


Fig 3.15 Multiplexing

## Time Division Multiplexing

When the transmission of data or signals is done in digital means, using the limited number of resources available, then the Time Division Multiplexing is used for the transmission of such data. Multiplexing is the process in communication, which merges two or more signals at its input into a single output, which when de-multiplexed, offers all those signals separately as they were.

### Time Division Space Switching

Time division switches may also employ space division switching techniques, whereas an appropriate mixture of both time and space division switching is advantageous in various circumstances.

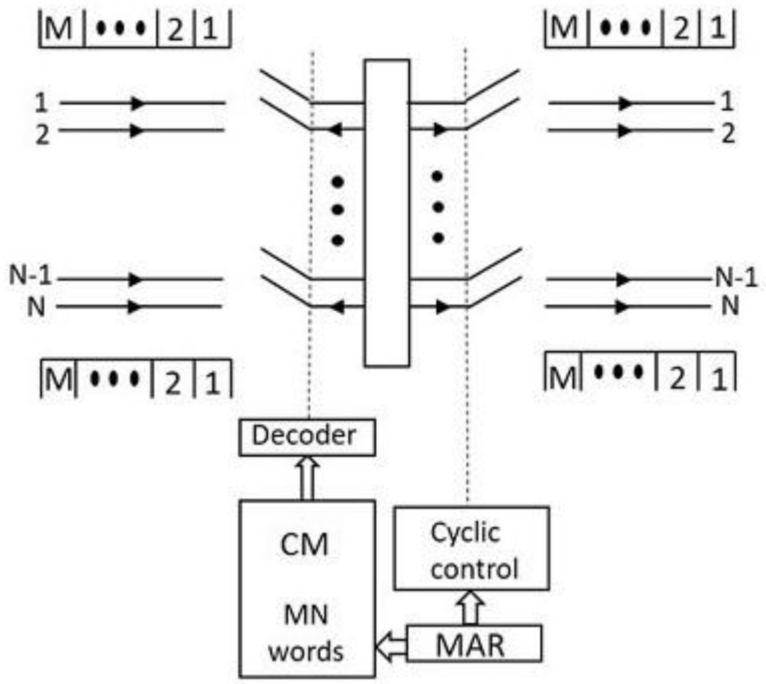


Fig 3.16 Time division space switching

Time Division Time Switching

The main advantage of time division time multiplexing technique is that, unlike time division space switching, it allows time slot interchange (TSI) of sample values. In TSI, a speech sample input during a time slot may be sent to the output during a different time slot, which implies a delay between reception and transmission of a sample.

Telephone exchange

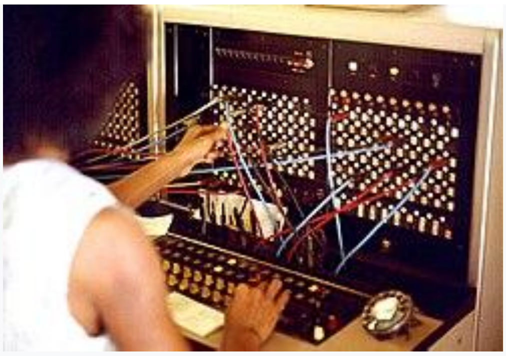

Fig 3.17 A telephone operator manually connecting calls with cord pairs at a telephone switchboard.

Fig 3.18 A modern central office, equipped for voice communication and broadband data.

## 3.2.3 Telephone exchange

A telephone exchange is a telecommunications system used in the public switched telephone network or in large enterprises. An exchange consists of electronic components and in older systems also human operators that interconnect (*switch*) telephone subscriber lines or virtual circuits of digital systems to establish telephone calls between subscribers.

Sector and Access Tandems

The switches in the tandem offices in the center of each of the LATAs in this illustration are providing both traditional sector tandem services (intraLATA) between local end offices and access tandem services to IXCs (interLATA).

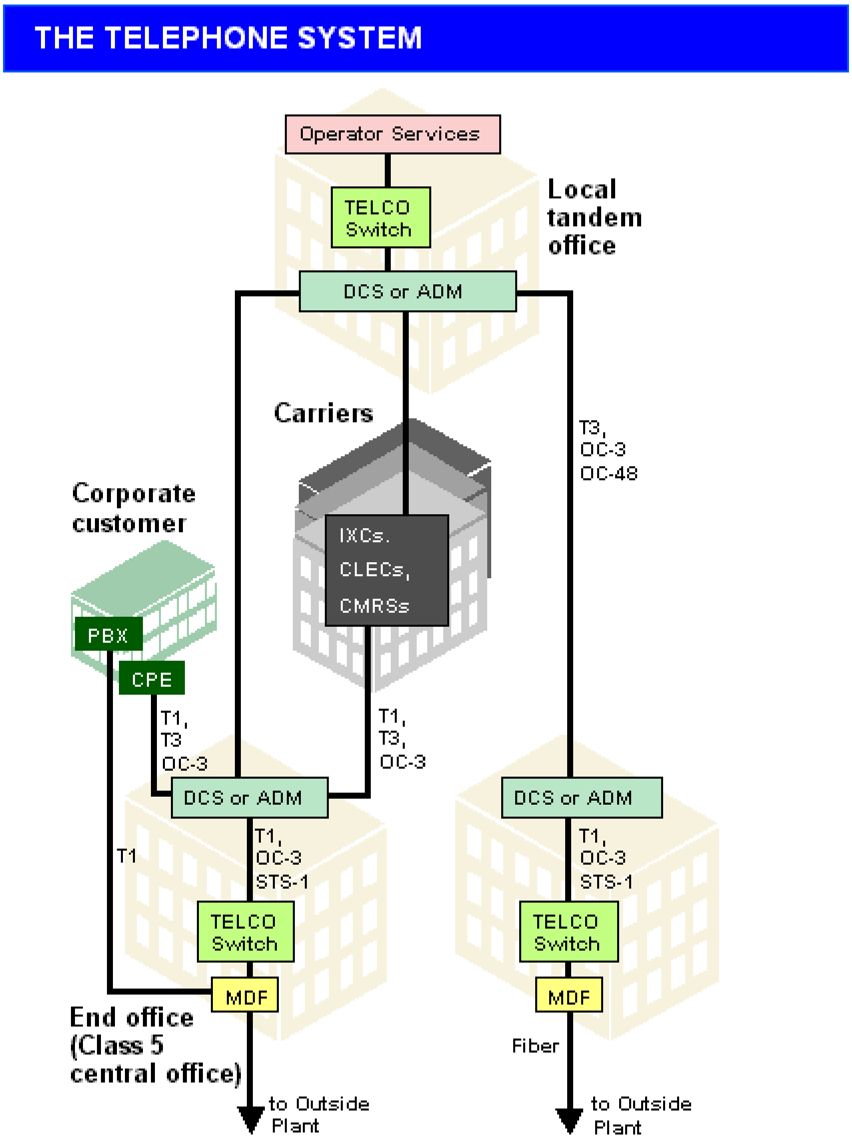


Fig 3.19 Telephone Exchange

## 3.2.4 Code modulation

Pulse-code modulation

(PCM) is a method used to digitally represent sampled analog signals. It is the standard form of digital audio in computers, compact discs, digital telephony and other digital audio applications. In a PCM stream, the amplitude of the analog signal is sampled regularly at uniform intervals, and each sample is quantized to the nearest value within a range of digital steps.

Linear pulse-code modulation

(LPCM) is a specific type of PCM where the quantization levels are linearly uniform.[5] This is in contrast to PCM encodings where quantization levels vary as a function of amplitude (as with the A-law algorithm or the μ-law algorithm). Though PCM is a more general term, it is often used to describe data encoded as LPCM.

# 3.3 Wireless communication

GSM

The GSM logo is used to identify compatible devices and equipment. The dots symbolize three clients in the home network and one roaming client.[1]

The Global System for Mobile Communications (GSM) is a standard developed by the European Telecommunications Standards Institute (ETSI) to describe the protocols for second-generation (2G) digital cellular networks used by mobile devices such as mobile phones and tablets. It was first deployed in Finland in December 1991.[2]By the mid-2010s, it became a global standard for mobile communications achieving over 90% market share, and operating in over 193 countries and territories.

### 3.3.1 Network structure

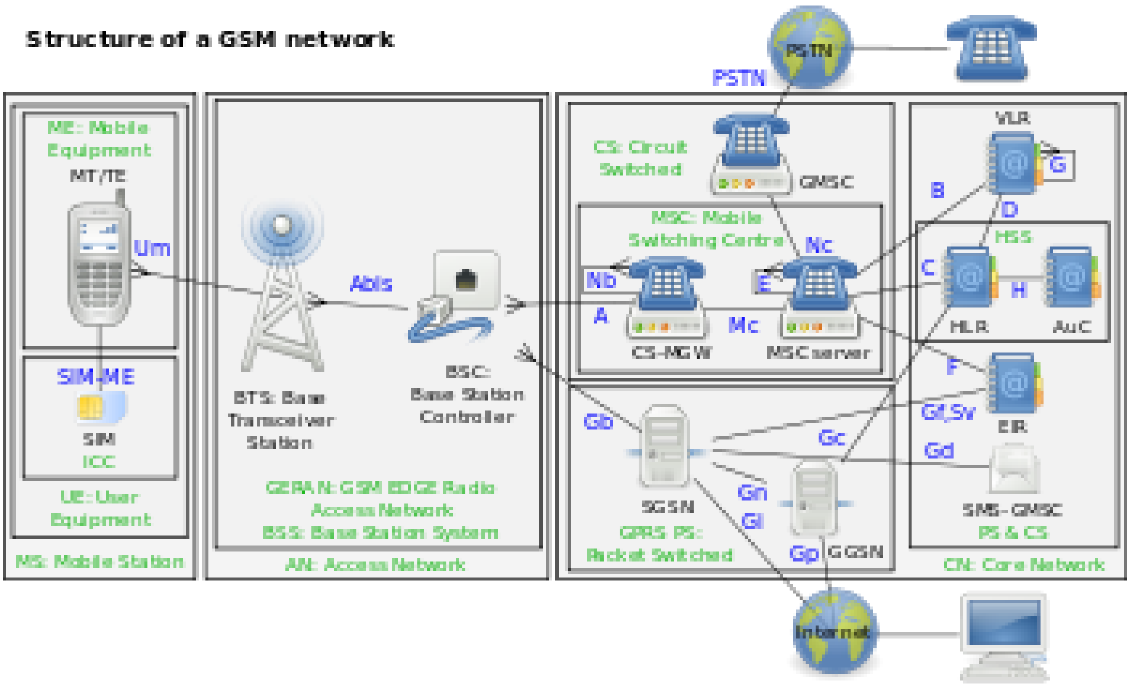


Fig 3.20 GSM network

The network is structured into several discrete sections:

- Base station subsystem – the base stations and their controllers
- Network and Switching Subsystem – the part of the network most similar to a fixed network, sometimes just called the "core network"
- GPRS Core Network – the optional part which allows packet-based Internet connections
- Operations support system (OSS) – network maintenance Base station subsystem

Fig 3.21 GSM cell site antennas in the Deutsches Museum, Munich, Germany

GSM is a cellular network, which means that cell phones connect to it by searching for cells in the immediate vicinity. There are five different cell sizes in a GSM network—macro, micro, pico, femto, and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average rooftop level. Micro cells are cells whose antenna height is under average rooftop level; they are typically used in urban areas.

## General Packet Radio Service

General Packet Radio Service (GPRS) is a packet oriented mobile data standard on the 2G and 3G cellular communication network's global system for mobile communications (GSM). GPRS was established by European Telecommunications Standards Institute (ETSI) in response to the earlier CDPD and i-mode packet-switched cellular technologies. It is now maintained by the 3rd Generation Partnership Project (3GPP).[1][2]

GPRS is typically sold according to the total volume of data transferred during the billing cycle, in contrast with circuit switched data, which is usually billed per minute of connection time, or sometimes by one-third minute increments. Usage above the GPRS bundled data cap may be charged per MB of data, speed limited, or disallowed.

## 3.3.2 TOWER

A cell site, cell tower, or cellular base station is a cellular-enabled mobile device site where antennae and electronic communications equipment are placed—typically on a radio mast, tower, or other raised structure—to create a cell (or adjacent cells) in a cellular network. The raised structure typically supports antenna and one or more sets of transmitter/receivers transceivers, digital signal processors, control electronics, a GPS receiver for timing (for CDMA2000/IS-95 or GSMsystems), primary and backup electrical power sources, and sheltering.

Fig 3.22 Tower

Range

The working range of a cell site (the range which mobile devices connects reliably to the cell site) is not a fixed figure. It will depend on a number of factors, including, but not limited to:

- Height of antenna over surrounding terrain (Line-of-sight propagation).
- The frequency of signal in use.
- The transmitters rated power.
- The required uplink/downlink data rate of the subscriber's device[4]
- The directional characteristics of the site antenna array.
- Reflection and absorption of radio energy by buildings or vegetation.
- It may also be limited by local geographical or regulatory factors and weather conditions.
- In addition there are timing limitations in some technologies (e.g., even in free space, GSM would be limited to 35 km, with 70 km being possible with special equipment)

## 3.3.3 Antenna (radio)

In radio engineering, an antenna is the interface between radio waves propagating through space and electric currents moving in metal conductors, used with a transmitter or receiver.[1] In transmission, a radio transmitter supplies an electric current to the antenna's terminals, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). In reception, an antenna intercepts some of the power of a radio wave in order to produce an electric current at its terminals, that is applied to a receiver to be amplified. Antennas are essential components of all radio equipment.

The Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular system for networks based on the GSM standard. Developed and maintained by the 3GPP (3rd Generation Partnership Project), UMTS is a component of the International Telecommunications Union IMT-2000 standard set and compares with the CDMA2000standard set for networks based on the competing cdmaOne technology. UMTS uses wideband code division multiple access (W-CDMA) radio access technology to offer greater spectral efficiency and bandwidth to mobile network operators.

3G UMTS Network Architecture
The UMTS network architecture can be divided into three main elements:

- *User Equipment (UE):* The User Equipment or UE is the name given to what was previous termed the mobile, or cellphone. The new name was chosen because the considerably greater functionality that the UE could have. It could also be anything between a mobile phone used for talking to a data terminal attached to a computer with no voice capability.
- *Radio Network Subsystem (RNS):* The RNS also known as the UMTS Radio Access Network, UTRAN, is the equivalent of the previous Base Station Subsystem or BSS in GSM. It provides and manages the air interface fort the overall network.
- *Core Network:* The core network provides all the central processing and management for the system. It is the equivalent of the GSM Network Switching Subsystem or NSS.
- *Serving GPRS Support Node (SGSN):* As the name implies, this entity was first developed when GPRS was introduced, and its use has been carried over into the UMTS network architecture. The SGSN provides a number of functions within the UMTS network architecture.

Microwave ODU

Microwave ODU (Outdoor Unit)

The term ODU is used in Split-Mount Microwave systems where an Indoor Unit (IDU) is typically mounted in an indoor location (or weatherproof shelter) connected via a coaxial cable to the ODU which is mounted on a rooftop or tower top location.

Fig 3.23 CableFree Microwave ODU

Often the ODU is direct mounted to a microwave antenna using “Slip fit” waveguide connection. In some cases, a Flexible Waveguidejumper is used to connect from the ODU to the antenna.

ODu Frequency bands and sub-bands

Each ODU is designed to operate over a predefined frequency sub-band. For example 21.2 – 23.6GHz for a 23GHz system, 17.7 – 19.7GHz for a 18GHz system and 24.5 – 26.5GHz for a 26GHz system as for ODUs. The sub-band is set in hardware (filters, diplexer) at time of manufacture and cannot be changed in the field.

1+0, 1+1, 2+0 Deployments

Microwave ODUs can be deployed in various configurations.

Microwave ODU in 1+0 Configuration with Antenna

The most common is 1+0 which has a single ODU, generally connected directly to the microwave antenna. 1+0 means “unprotected” in that there is no resilience or backup equipment or path.

IDU (In-Door Unit)

An IDU, or In-Door Unit, is a telecommunication device that is used in satellite television and Internet service to receive and decode satellite transmissions. An IDU is a box that connects to the user's television and/or router and contains a built-in satellite receiver that may also be connected to a satellite dish on the roof or exterior wall of the user's home. An IDU is responsible for receiving the satellite signals broadcasted by the user's satellite service provider and decoding them in order to provide the user with satellite television and/or Internet access.

# 3.4. COMPUTER COMMUNICATION NETWORKS

INTRODUCTION TO NETWORKS networking engineering is a complicated task, which involves software, firmware, chip level engineering, hardware, and electric pulses. To ease network engineering, the whole networking concept is divided into multiple layers. Each layer is involved in some particular task and is independent of all other layers. But as a whole, almost all networking tasks depend on all of these layers. Layers share data between them and they depend on each other only to take input and send output. Layered Tasks In layered architecture of Network Model, one whole network process is divided into small tasks. Each small task is then assigned to a particular layer which works dedicatedly to process the task only. Every layer does only specific work. In layered communication system, one layer of a host deals with the task done by or to be done by its peer layer at the same level on the remote host. The task is either initiated by layer at the lowest level or at the top most level. If the task is initiated by the-top most layer, it is passed on to the layer below it for further processing. The lower layer does the same thing, it processes the task and passes on to lower layer. If the task is initiated by lower most layer, then the reverse path is taken

## 3.4.1 OSI reference model (Open Systems Interconnection)

OSI (Open Systems Interconnection) is reference model for how applications can communicate over a network. A reference model is a conceptual framework for understanding relationships. The purpose of the OSI reference model is to guide vendors and developers so the digital communication products and software programs they create will interoperate, and to facilitate clear comparisons among communications tools. Most vendors involved in telecommunications make an attempt to describe their products and services in relation to the OSI model. And although useful for guiding discussion and evaluation, OSI is rarely actually implemented, as few network products or standard tools keep all related functions together in well-defined layers as related to the model. The TCP/IP protocols, which define the Internet, do not map cleanly to the OSI model. Developed by representatives of major computer and telecommunication companies beginning in 1983, OSI was originally intended to be a detailed specification of actual interfaces. Instead, the committee decided to establish a common reference model for which others could then develop detailed interfaces, which in turn could become standards. OSI was officially adopted as an international standard by the International Organization of Standards (ISO).

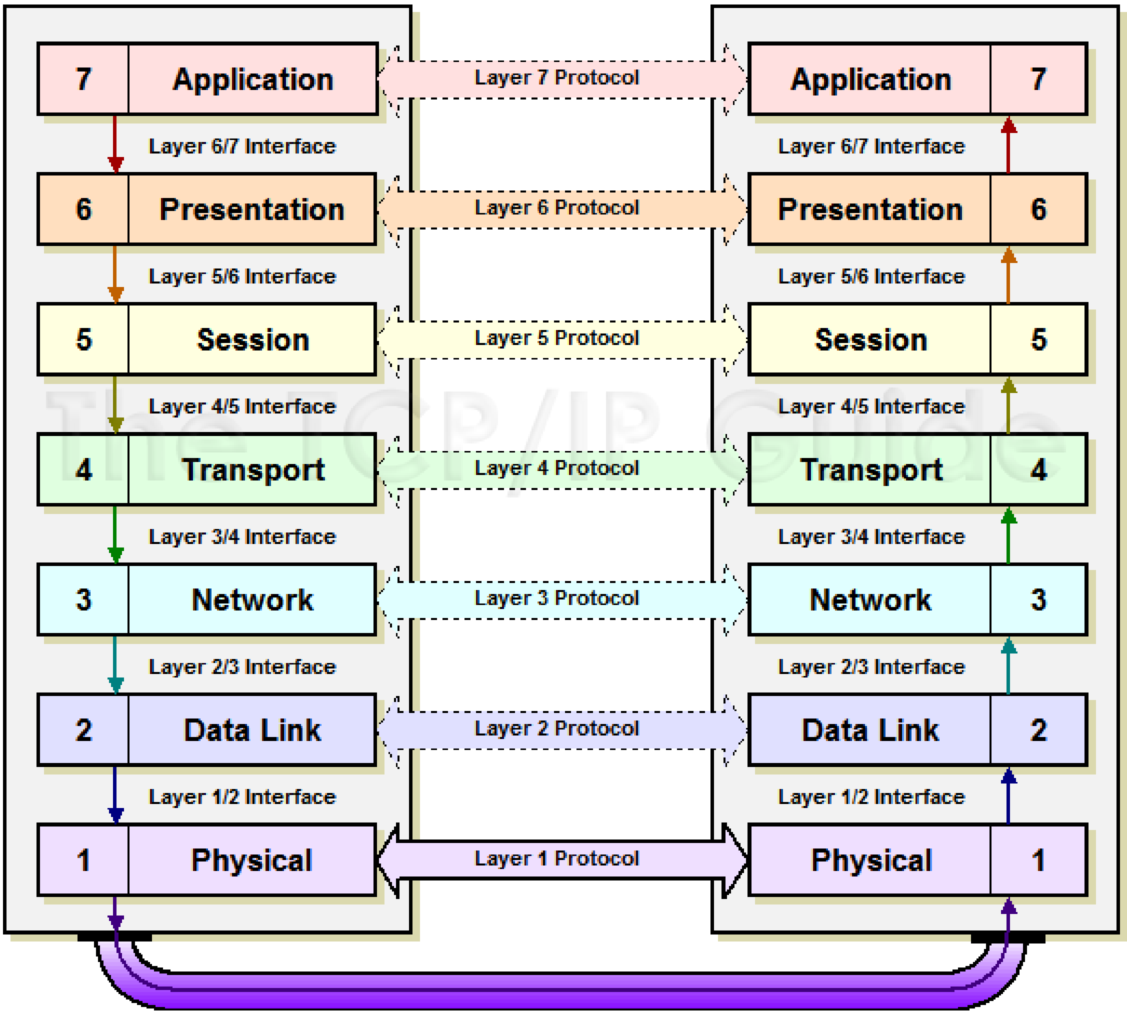


Fig 3.24 OSI reference model

## 3.4.2 The TCP/IP Protocol Suite

The TCP/IP protocol suite maps to a four-layer conceptual model known as the DARPA model, which was named after the U.S. government agency that initially developed TCP/IP. The four layers of the DARPA model are: Application, Transport, Internet, and Network Interface. Each layer in the DARPA model corresponds to one or more layers of the seven-layer OSI model. Figure 2-1 shows the architecture of the TCP/IP protocol suite.

The TCP/IP protocol suite has two sets of protocols at the Internet layer: • IPv4, also known as IP, is the Internet layer in common use today on private intranets and the Internet. • IPv6 is the new Internet layer that will eventually replace the existing IPv4 Internet layer.

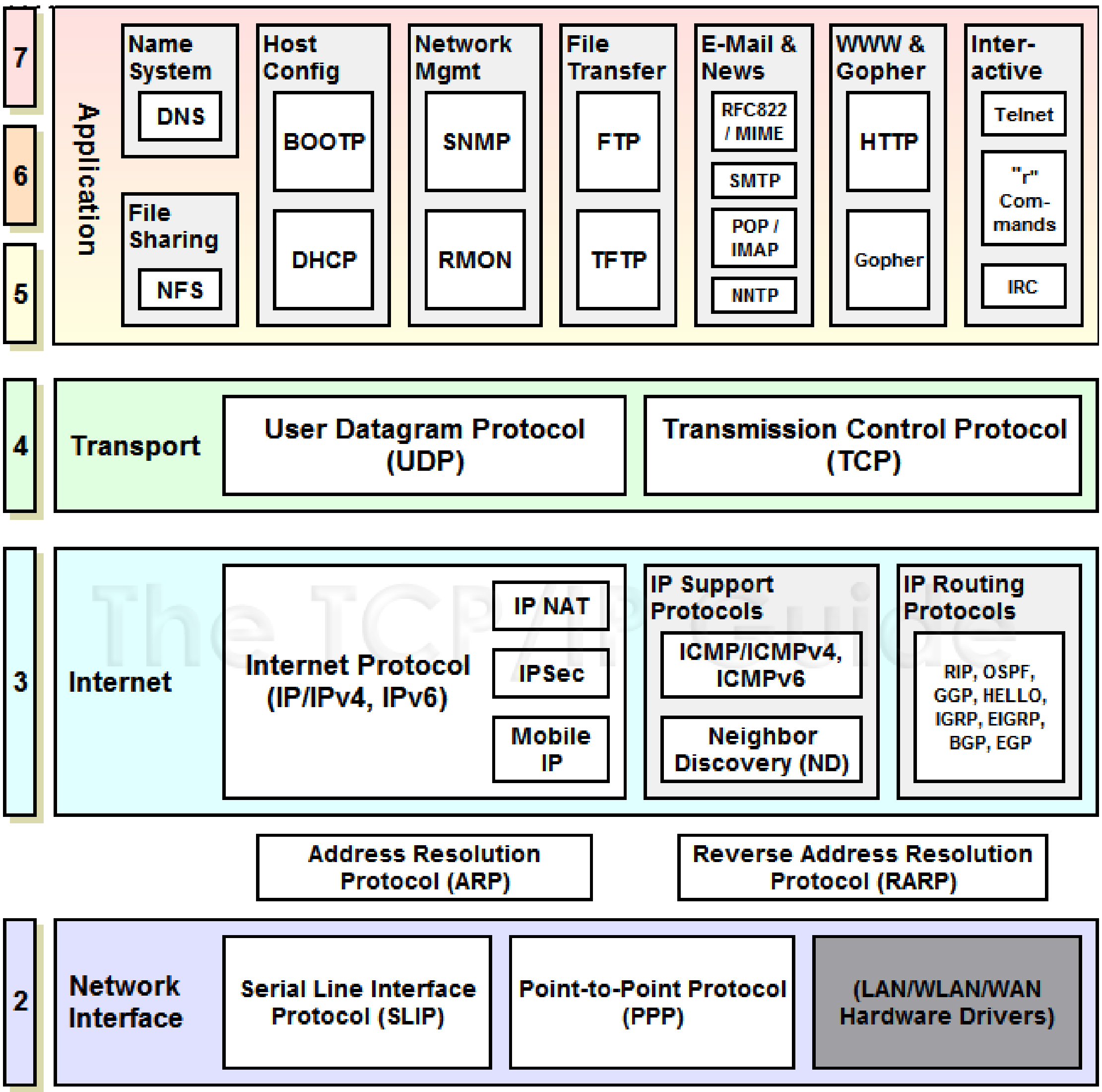


Fig 3.25 TCP/IP protocol suite

Network Interface Layer

The Network Interface layer (also called the Network Access layer) sends TCP/IP packets on the network medium and receives TCP/IP packets off the network medium. TCP/IP was designed to be independent of the network access method, frame format, and medium. Therefore, you can use TCP/IP to communicate across differing network types that use LAN technologies—such as Ethernet and 802.11 wireless LAN—and WAN technologies—such as Frame Relay and Asynchronous Transfer Mode (ATM). By being independent of any specific network technology, TCP/IP can be adapted to new technologies. The Network Interface layer of the DARPA model encompasses the Data Link and Physical layers of the OSI model. The Internet layer of the DARPA model does not take advantage of sequencing and acknowledgment services that might be present in the Data Link layer of the OSI model. The Internet layer assumes an unreliable Network Interface layer and that reliable communications through session establishment and the sequencing and acknowledgment of packets is the responsibility of either the Transport layer or the Application layer.

Internet Layer

The Internet layer responsibilities include addressing, packaging, and routing functions. The Internet layer is analogous to the Network layer of the OSI model. The core protocols for the IPv4 Internet layer consist of the following:

- The Address Resolution Protocol (ARP) resolves the Internet layer address to a Network Interface layer address such as a hardware address. COMPUTER COMMUNICATION NETWORKS Department of ECE, ACE Page 6
- The Internet Protocol (IP) is a routable protocol that addresses, routes, fragments, and reassembles packets.
- The Internet Control Message Protocol (ICMP) reports errors and other information to help you diagnose unsuccessful packet delivery.
- The Internet Group Management Protocol (IGMP) manages IP multicast groups.
- IPv6 is a routable protocol that addresses and routes packets.
- The Internet Control Message Protocol for IPv6 (ICMPv6) reports errors and other information to help you diagnose unsuccessful packet delivery.
- The Neighbor Discovery (ND) protocol manages the interactions between neighboring IPv6 nodes.
- The Multicast Listener Discovery (MLD) protocol manages IPv6 multicast groups.

Transport Layer

The Transport layer (also known as the Host-to-Host Transport layer) provides the Application layer with session and datagram communication services. The Transport layer encompasses the responsibilities of the OSI Transport layer. The core protocols of the Transport layer are TCP and UDP. TCP provides a one-to-one, connection-oriented, reliable communications service. TCP establishes connections, sequences and acknowledges packets sent, and recovers packets lost during transmission. In contrast to TCP, UDP provides a one-to-one or one-to-many, connectionless, unreliable communications service. UDP is used when the amount of data to be transferred is small (such as the data that would fit into a single packet), when an application developer does not want the overhead associated with TCP connections, or when the applications or upper-layer protocols provide reliable delivery. TCP and UDP operate over both IPv4 and IPv6 Internet layers. Note The Internet Protocol (TCP/IP) component of Windows contains separate versions of the TCP and UDP protocols than the Microsoft TCP/IP Version 6 component does. The versions in the Microsoft TCP/IP Version 6 component are functionally equivalent to those provided with the Microsoft Windows NT® 4.0 operating systems and contain all the most recent security updates. The existence of separate protocol components with their own versions of TCP and UDP is known as a dual stack architecture. The ideal architecture is known as a dual IP layer, in COMPUTER COMMUNICATION NETWORKS Department of ECE, ACE Page 7 which the same versions of TCP and UDP operate over both IPv4 and IPv6 (as Figure 2-1 shows). Windows Vista has a dual IP layer architecture for the TCP/IP protocol components.

Application Layer

The Application layer allows applications to access the services of the other layers, and it defines the protocols that applications use to exchange data. The Application layer contains many protocols, and more are always being developed. The most widely known Application layer protocols help users exchange information:

- The Hypertext Transfer Protocol (HTTP) transfers files that make up pages on the World Wide Web.
- The File Transfer Protocol (FTP) transfers individual files, typically for an interactive user session.
- The Simple Mail Transfer Protocol (SMTP) transfers mail messages and attachments.

Additionally, the following Application layer protocols help you use and manage TCP/IP networks:

- The Domain Name System (DNS) protocol resolves a host name, such as www.microsoft.com, to an IP address and copies name information between DNS servers.
- The Routing Information Protocol (RIP) is a protocol that routers use to exchange routing information on an IP network.
- The Simple Network Management Protocol (SNMP) collects and exchanges network management information between a network management console and network devices such as routers, bridges, and servers. Windows Sockets and NetBIOS are examples of Application layer interfaces for TCP/IP applications.

IPv4 Internet Layer

The IPv4 Internet layer consists of the following protocols:

- ARP
- IP (IPv4)
- ICMP
- IGMP

About Slash Notation

Your Firebox uses *slash notation*, also known as CIDR (Classless Inter-Domain Routing) notation, for many purposes, such as policy configuration. You use slash notation differently for IPv4 and IPv6 addresses.

IPv4

Slash notation is a compact way to show or write an IPv4 subnet mask. When you use slash notation, you write the IP address, a forward slash (/), and the subnet mask number.

To find the subnet mask number:

1. Convert the decimal representation of the subnet mask to a binary representation.
2. Count each “1” in the subnet mask. The total is the subnet mask number.

For example, to write the IPv4 address 192.168.42.23 with a subnet mask of 255.255.255.0 in slash notation:

1. Convert the subnet mask to binary.
   *In this example, the binary representation of 255.255.255.0 is: 11111111.11111111.11111111.00000000.*
2. Count each *1* in the subnet mask.
   *In this example, there are twenty-four (24).*
3. Write the original IP address, a forward slash (/), and then the number from Step 2.
   *The result is 192.168.42.23/24.*

| Network Mask | Slash Equivalent |
|---|---|
| 255.0.0.0 | /8 |
| 255.255.0.0 | /16 |
| 255.255.255.0 | /24 |
| 255.255.255.128 | /25 |

| Network Mask | Slash Equivalent |
|---|---|
| 255.255.255.192 | /26 |
| 255.255.255.224 | /27 |
| 255.255.255.240 | /28 |
| 255.255.255.248 | /29 |
| 255.255.255.252 | /30 |
| 255.255.255.254 | /31 |
| 255.255.255.255 | /32 |

Table 3.9. This table shows common network masks and their equivalents in slash notation.

*Subnet Mask*

A subnet mask is a 32-bit number used to differentiate the network component of an IP address by dividing the IP address into a network address and host address. It does so with bit arithmetic whereby a network address is bit multiplied by the subnet mask reveal the underlying subnetwork. Like the IP address, a subnet mask is written using the "dotted-decimal" notation.

A subnet mask is also known as an address mask.

Subnet masks are used to design subnetworks, or subnets, that connect local networks. It determines both the number and size of subnets where the size of a subnet is the number of hosts that can be addressed.

# CHAPTER 4

# Reflection notes

## 4.1 Error control in data link layer

Error control in data link layer is the process of detecting and correcting data frames that have been corrupted or lost during transmission.

In case of lost or corrupted frames, the receiver does not receive the correct data-frame and sender is ignorant about the loss. Data link layer follows a technique to detect transit errors and take necessary actions, which is retransmission of frames whenever error is detected or frame is lost. The process is called Automatic Repeat Request (ARQ).

Phases in Error Control

The error control mechanism in data link layer involves the following phases:

- Detection of Error − Transmission error, if any, is detected by either the sender or the receiver.
- Acknowledgment − acknowledgment may be positive or negative.
  - Positive ACK − on receiving a correct frame, the receiver sends a positive acknowledge.
  - Negative ACK − on receiving a damaged frame or a duplicate frame, the receiver sends a negative acknowledgment back to the sender.
- Retransmission − the sender maintains a clock and sets a timeout period. If an acknowledgment of a data-frame previously transmitted does not arrive before the timeout, or a negative acknowledgment is received, the sender retransmits the frame.

Error Control Techniques

There are three main techniques for error control:


Fig 4.1 Stop and wait

- Stop and Wait ARQ

  This protocol involves the following transitions:

  - A timeout counter is maintained by the sender, which is started when a frame is sent.
  - If the sender receives acknowledgment of the sent frame within time, the sender is confirmed about successful delivery of the frame. It then transmits the next frame in queue.
  - If the sender does not receive the acknowledgment within time, the sender assumes that either the frame or its acknowledgment is lost in transit. It then retransmits the frame.
  - If the sender receives a negative acknowledgment, the sender retransmits the frame.

- Go-Back-N ARQ

  The working principle of this protocol is:

  - The sender has buffers called sending window.
  - The sender sends multiple frames based upon the sending-window size, without receiving the acknowledgment of the previous ones.
  - The receiver receives frames one by one. It keeps track of incoming frame's sequence number and sends the corresponding acknowledgment frames.
  - After the sender has sent all the frames in window, it checks up to what sequence number it has received positive acknowledgment.
  - If the sender has received positive acknowledgment for all the frames, it sends next set of frames.
  - If sender receives NACK or has not receive any ACK for a particular frame, it retransmits all the frames after which it does not receive any positive ACK.

- Selective Repeat ARQ

- Both the sender and the receiver have buffers called sending window and receiving window respectively.
- The sender sends multiple frames based upon the sending-window size, without receiving the acknowledgment of the previous ones.
- The receiver also receives multiple frames within the receiving window size.
- The receiver keeps track of incoming frame's sequence numbers, buffers the frames in memory.
- It sends ACK for all successfully received frames and sends NACK for only frames which are missing or damaged.
- The sender in this case, sends only packet for which NACK is received.

## 4.2 Communication skills

Being an effective communicator takes real skill. Effective communication skills have to be developed, honed and added to on an ongoing basis. They are the heart of your interpersonal skills and the greater your awareness of how it all works, the more effective your communication will become. To be effective in business, you have to communicate well. To be a good manager, you have to communicate exceptionally well. We could write a book about the importance of communication key skills. But, for now, we will start with some essentials for becoming a more effective communicator.

### Communication cycle

There is a neat communication cycle we've come across that can help you understand how to make communication work better. It means that you can take responsibility for every stage of the Communication Cycle: Spoken - Heard - Understood - Agreed To - Acted On - Implemented. Be aware of where you or others tend to fall off the cycle.

### Needing to be right

This is one area we all know about - the need to be right and in turn for the other person to be wrong. One skill that does need practice is to let go of needing to be right. Think of it as presenting information or a point of view rather than having to bludgeon someone else with your arguments. If you want to promote effective relationships, this is one of the greatest communication key skills you can have is to be able to change what you want from a communication.

### Conflict resolution

One of the purposes of conflict is to arrive at a resolution, so if you avoid conflict, the problem usually (though not always) gets worse. The earlier you can identify that there is a problem and intervene, the better it will be. Good communication skills require you to be able to resolve conflict.

### Agreement

Find something (anything will do) in the other person's argument which you can genuinely agree with. This is a great way to take the wind out of someone's sails and ensure you don't get drawn into an insoluble argument. People usually won't listen until they feel heard.

### Bridge building

Really listen to what the other person is saying - they usually give a lot of information without realizing it. Building bridges by making an offer can help enormously, as can changing what you want.

### 'I', not 'you'

Use 'I' statements, not 'You' statements to avoid blaming. This also means that you take responsibility for how you feel, rather than making the other person responsible for making things all right for you.

### Attitude

You can change the direction of communication if you change your attitude. There is no one attitude that's the 'right' one to have, though being direct and clear certainly helps.

### Effective listening and responding

You can have a tremendous influence on communication as the listener and the responder. When we get little or no response from the listener, we often project our assumptions onto them about what they are thinking (and usually we assume they aren't thinking good things about us!).

### Be positive

Use affirmation and encouragement to get the best out of people. Notice when others do things well (even if it's part of their daily routine). This shows you're being attentive; most people respond well when they know that others are aware of what they do. Quite simply, the workplace can be a far better place to be if you consciously sprinkle your communication with positive feedback.

### A final thought

Don't leave the business of communication to chance. Raise your awareness, develop your skills and practice every day.

## 4.3 Learning skills

The 21st century learning skills are often called the 4 C’s: critical thinking, creative thinking, communicating, and collaborating. These skills help students learn, and so they are vital to success in school and beyond. Critical thinking is focused, careful analysis of something to better understand it. When people speak of “left brain” activity, they are usually referring to critical thinking. Here are some of the main critical-thinking abilities:

- Analysing is breaking something down into its parts, examining each part, and noting how the parts fit together.
- Arguing is using a series of statements connected logically together, backed by evidence, to reach a conclusion.
- Classifying is identifying the types or groups of something, showing how each category is distinct from the others.
- Comparing and contrasting is pointing out the similarities and differences between two or more subjects.
- Defining is explaining the meaning of a term using denotation, connotation, example, etymology, synonyms, and antonyms.
- Describing is explaining the traits of something, such as size, shape, weight, color, use, origin, value, condition, location, and so on.
- Evaluating is deciding on the worth of something by comparing it against an accepted standard of value.
- Explaining is telling what something is or how it works so that others can understand it.
- Problem solving is analysing the causes and effects of a problem and finding a way to stop the causes or the effects.
- Tracking cause and effect is determining why something is happening and what results from it.

## 4.4 Conclusion

The basics of Optical Fiber module provides a vision to the functioning of optical fibers and the newest way of communication using them.it clears the basics from the beginning from introduction of optical fiber It covers all the basics, a stepping stone to the new technology. It talks about the types of optical fiber, transmission of optical fiber, transmitter, losses of optical fiber, connector and splicing, giving an opportunity to understand this technology as and when it comes in application.

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