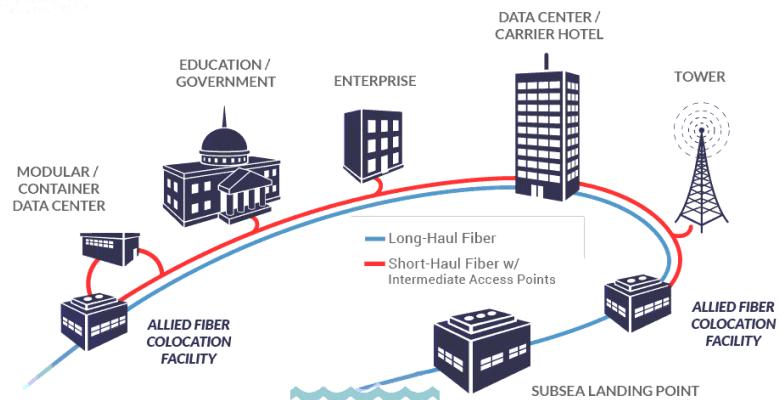
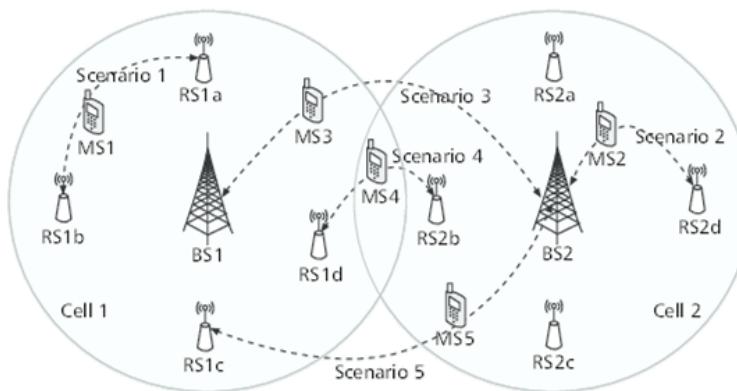
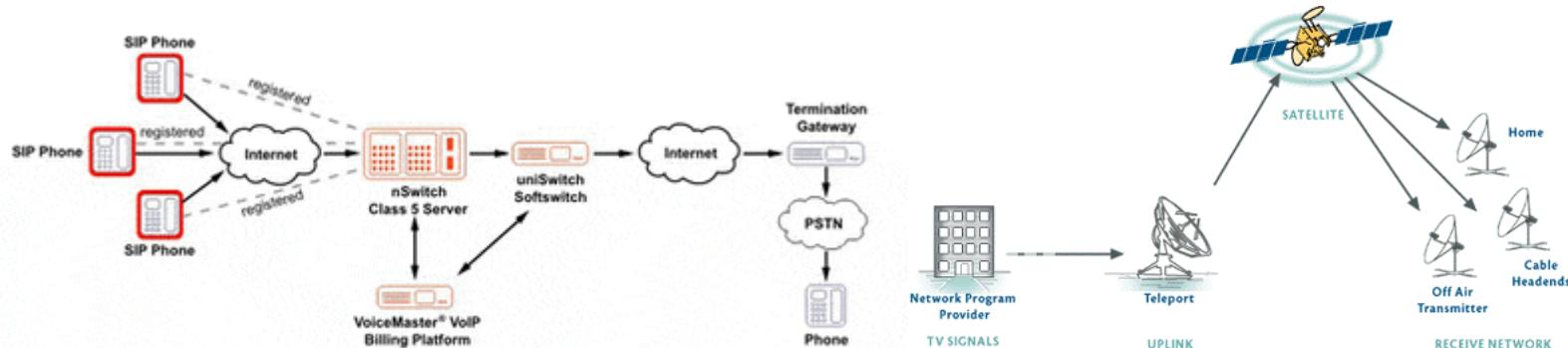


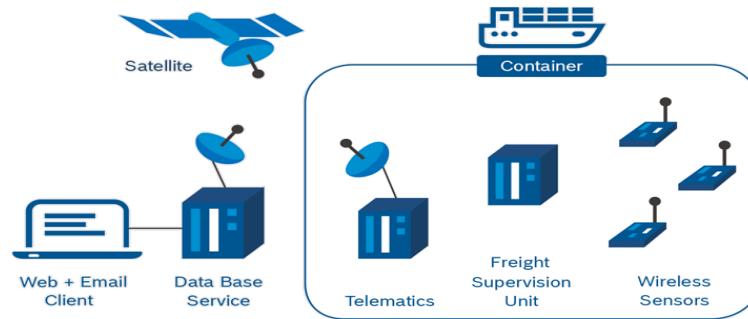


DATA and DIGITAL COMMUNICATIONS

INTRODUCTION TO TELECOMMUNICATIONS
CHAPTER 1



Chapter 1

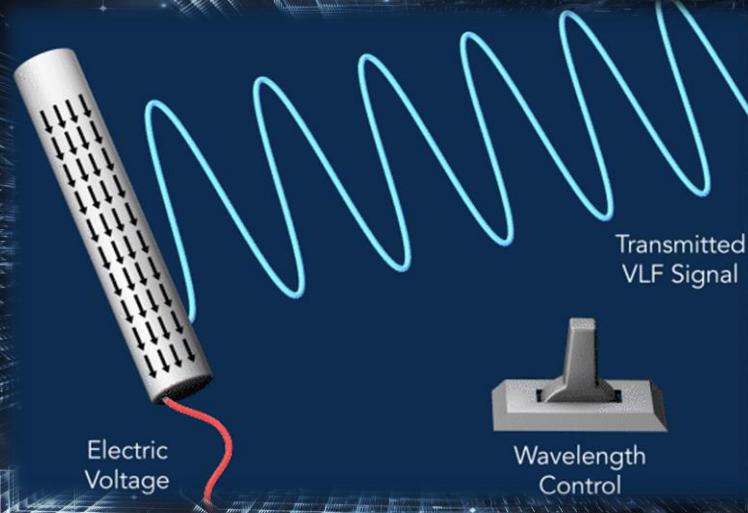


Introduction to Telecommunications

- Principles of Communications Systems
- Digital and Mobile Telephony
- Terrestrial and Satellite Communications
- Fiber Optic Systems and Technologies

Module 1

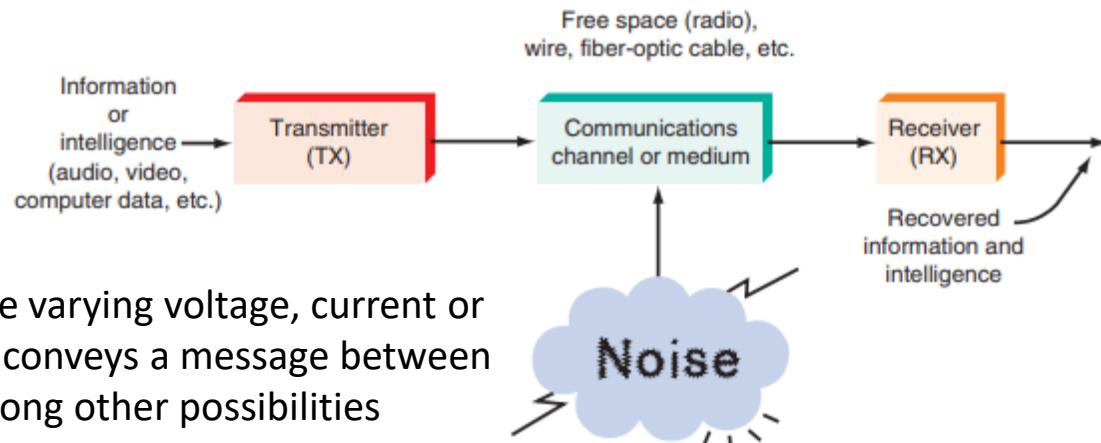
Principles of Communications Systems



Principles of Communications Systems

Electronic Communications

- transmission, reception, and processing of information or message (in the form of signals) between two or more locations with the use of circuits

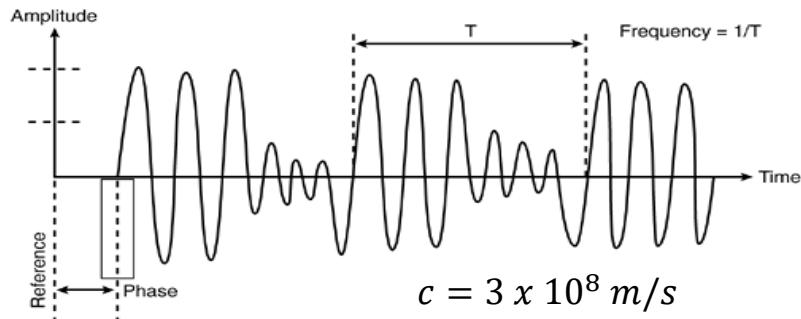


Signal is a time varying voltage, current or EM wave that conveys a message between observers, among other possibilities

Principles of Communications Systems

Properties of Signals

- Amplitude – measure of the signal intensity, loudness, power, strength, or level
- Wavelength – distance between two identical points of neighboring cycles of a wave signal traveling in space or in any physical medium, measured in *meters* (m)
- Period – time it takes for a signal to complete one cycle, measured in *seconds* (s)
- Frequency – number of cycles per unit time, measured in *Hertz* (Hz)
- Bandwidth – range of frequencies within a given band, measured in *Hertz* (Hz)
- Phase – position of a point in time (an instant) on a signal cycle, measured in *radian degrees*



Principles of Communications Systems

Transmitter Components

- Signal Input Interface
 - Power Supply
 - Local Oscillator
 - Modulator
 - RF Amplifier
 - Impedance Matching Circuit



Principles of Communications Systems

Receiver Components

- Signal Input Interface
- RF and IF Amplifiers
- Beat Frequency Oscillator
- Automatic Gain Control
- Phase Detector
- Bandwidth Filter
- Audio Limiter
- Power Supply
- Signal Output Interface



Principles of Communications Systems

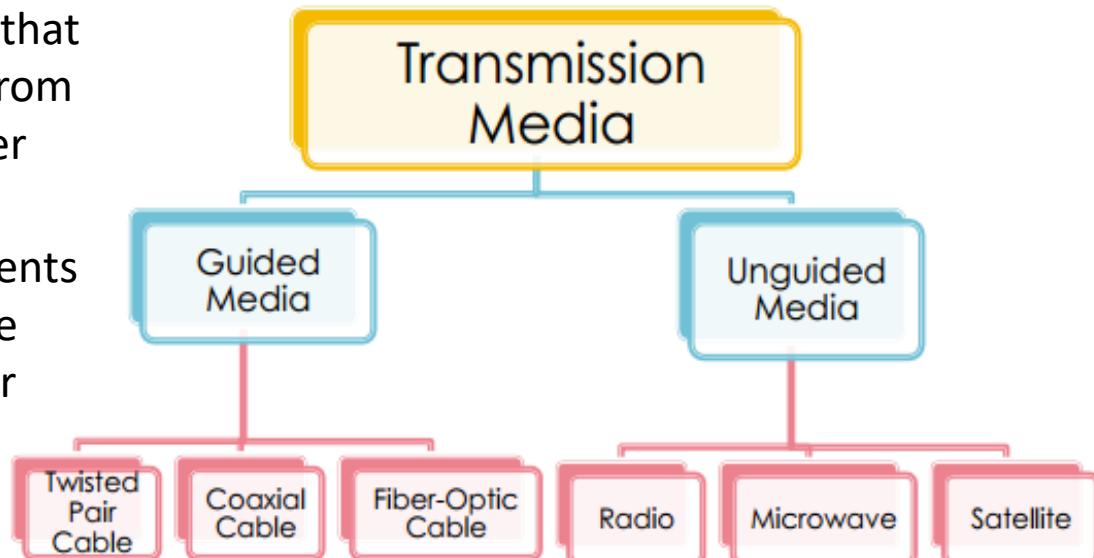
Generally speaking, a **transceiver** is a device that can both transmit and receive signals, whereas a **transponder** is a component programmed to monitor incoming signals and with a preprogrammed reply in the communication network.



Principles of Communications Systems

Transmission Media

- communication channel that carries the information from the sender to the receiver
- physical path between communication components that can mediate the propagation of signals for the purposes of telecommunication



Principles of Communications Systems

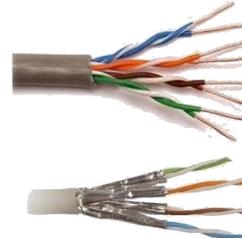
Transmission Lines



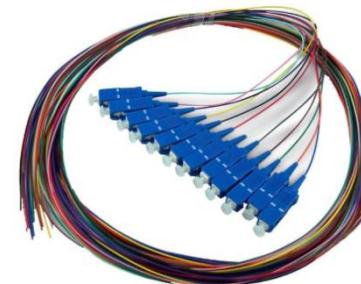
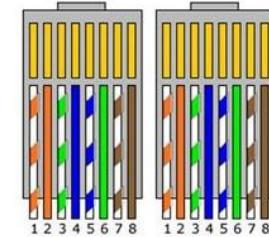
Coax



Waveguide



Twister Pair



Fiber Optics

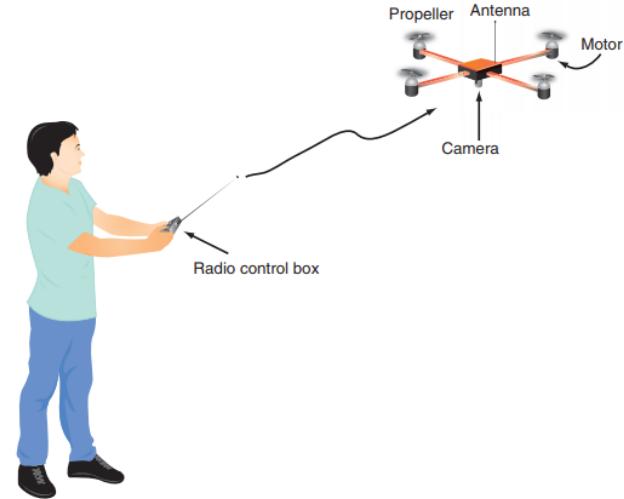
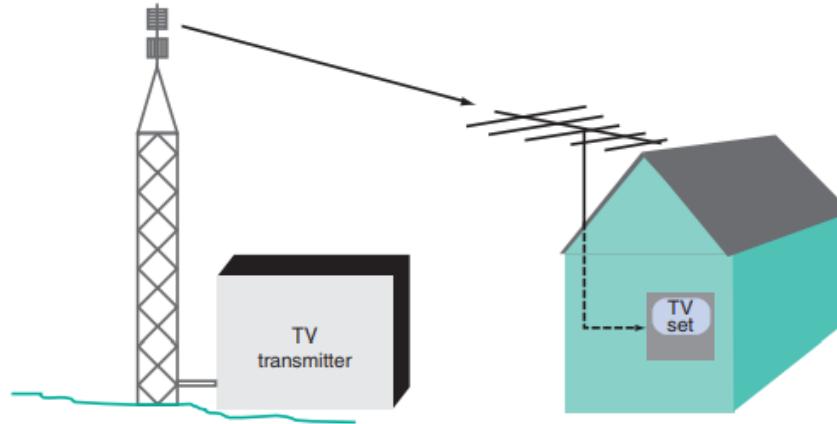
Principles of Communications Systems

Antenna



Principles of Communications Systems

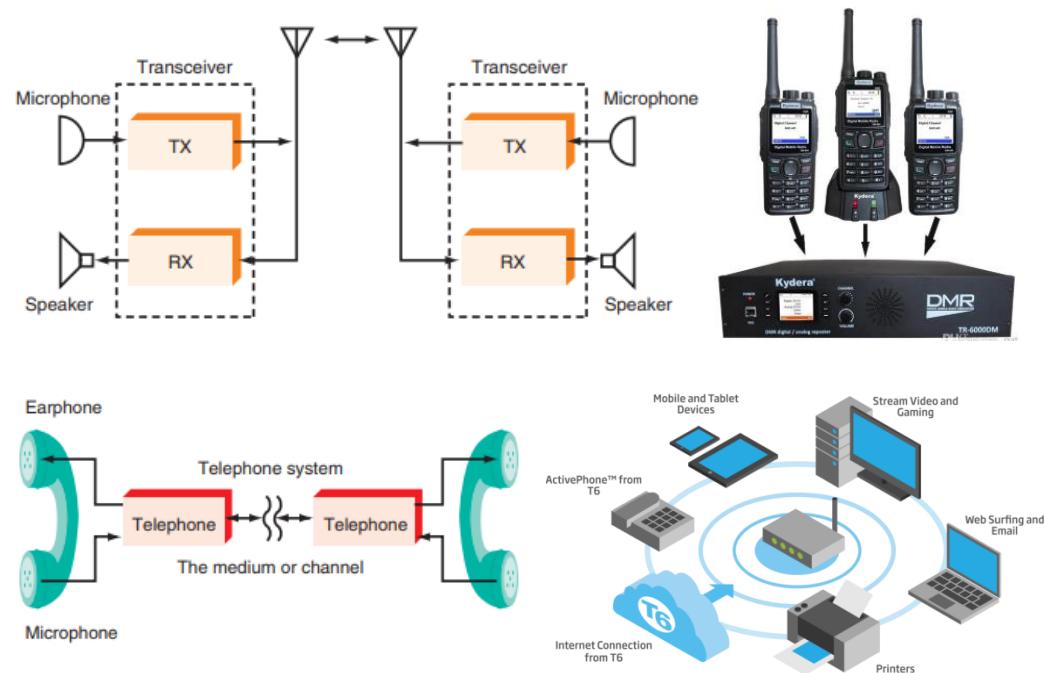
Transmission Modes



- Simplex – one-way communication, which is the simplest way to conduct electronic communication

Principles of Communications Systems

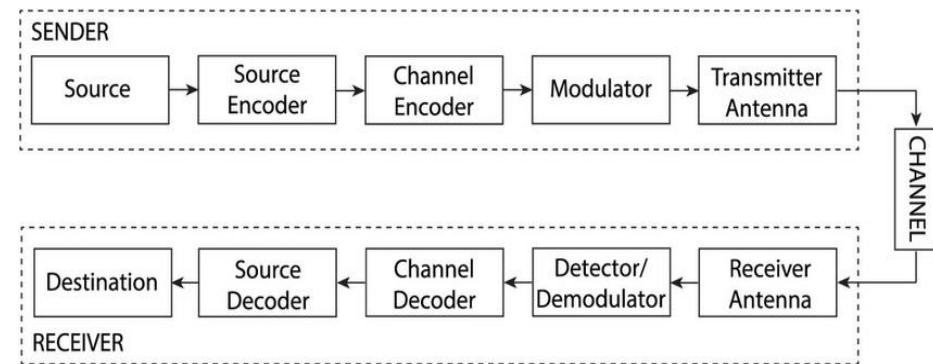
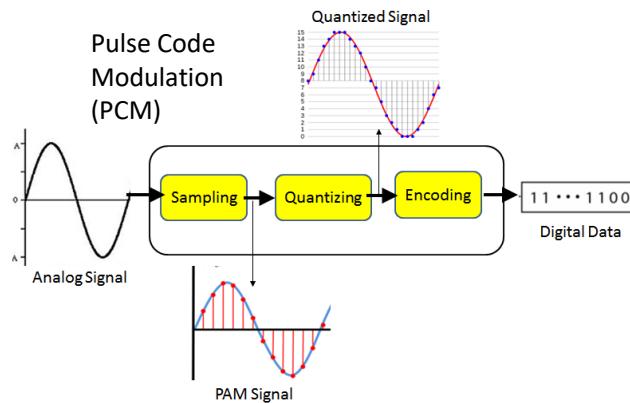
- Half-Duplex – two-way communication in which only one party transmits at a time
- Full-Duplex – two-way communication in which each party can transmit and receive signals simultaneously with each other



Principles of Communications Systems

Digital Communications

- mode of communication where the information or the thought is encoded digitally as discrete signals and electronically transferred to the recipients



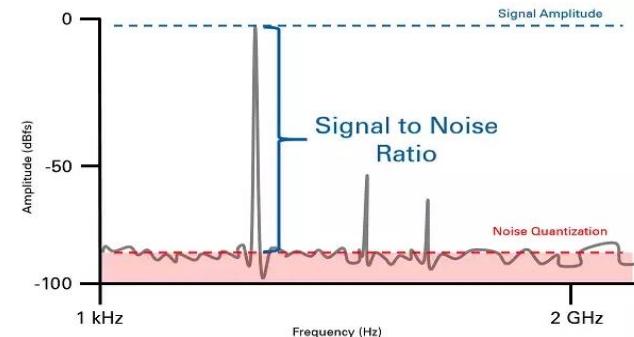
Basic Digital Communication System

Principles of Communications Systems

Information Theory studies the quantification, storage, and communication of information. It is the mathematical treatment of the concepts, parameters and rules governing the transmission of messages through communication systems

$$C = B \log_2 (1+S/N)$$

bandwidth of the channel
↓
Channel capacity in bits/s
↑
Shannon-Hartley Theorem
signal-to-noise ratio



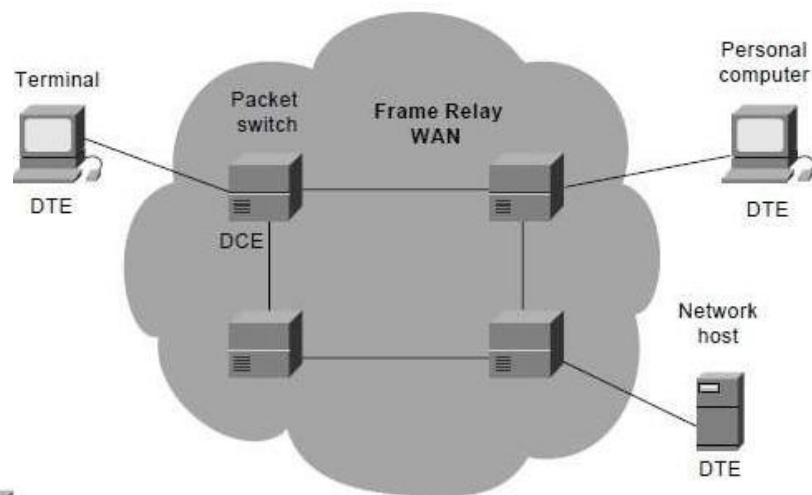
$$SNR = \frac{P_{signal}}{P_{noise}}$$

Wanted component
Unwanted component

Principles of Communications Systems

Data Communications

- process of using computing and communication technologies to transfer data from one place to another, and vice versa
- transmission of digital data between two or more computers

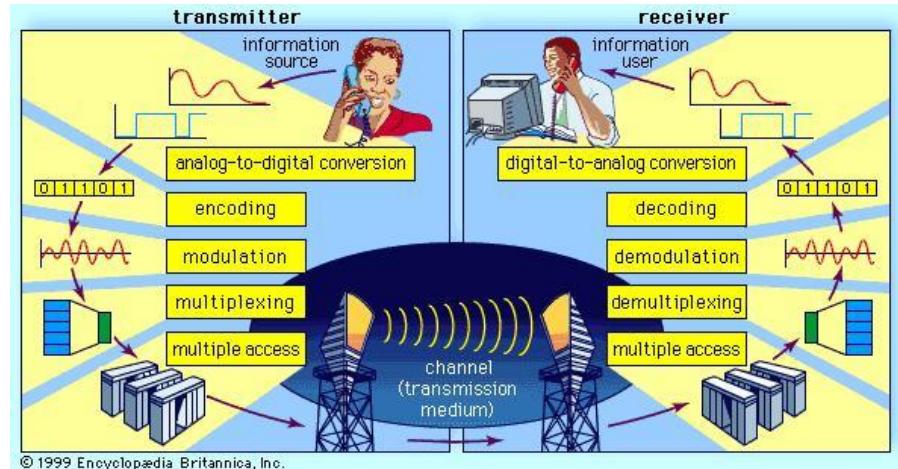
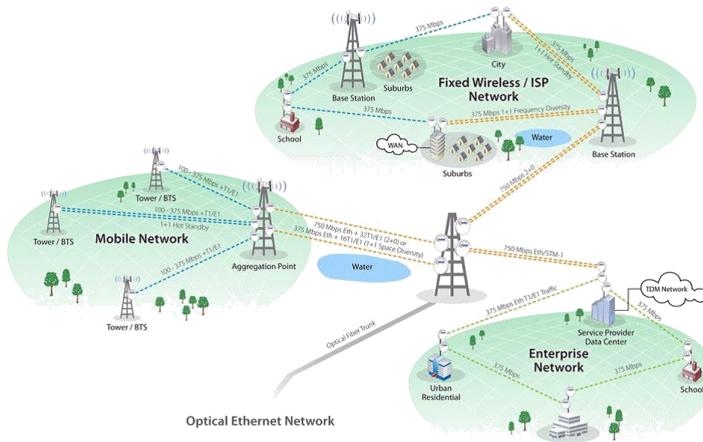


DTE – Data Terminal Equipment
DCE – Data Communications Equipment

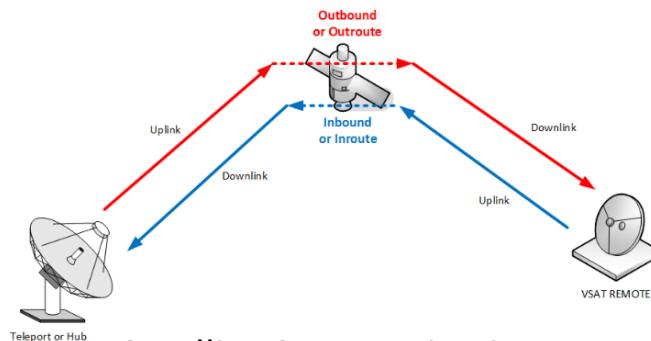
Principles of Communications Systems

Telecommunications

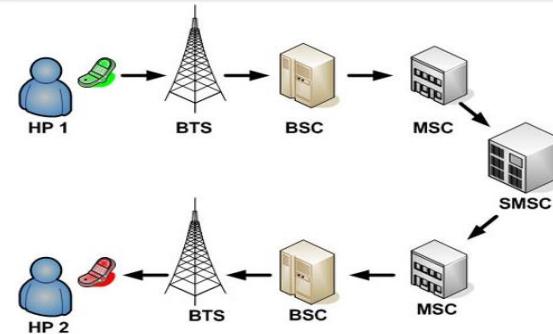
- exchange of information over significant distances by electronic means and refers to all types of voice, data and video transmission.



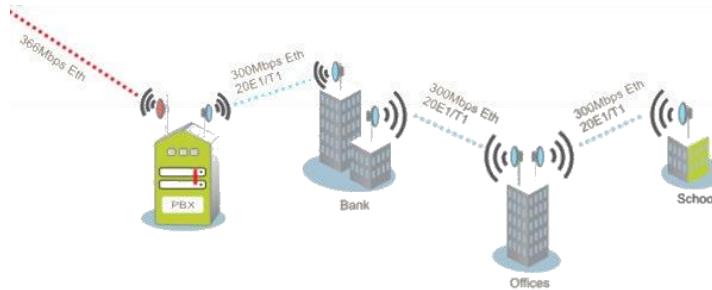
Principles of Communications Systems



Satellite Communications



Cellular Communications



Terrestrial Microwave Communications



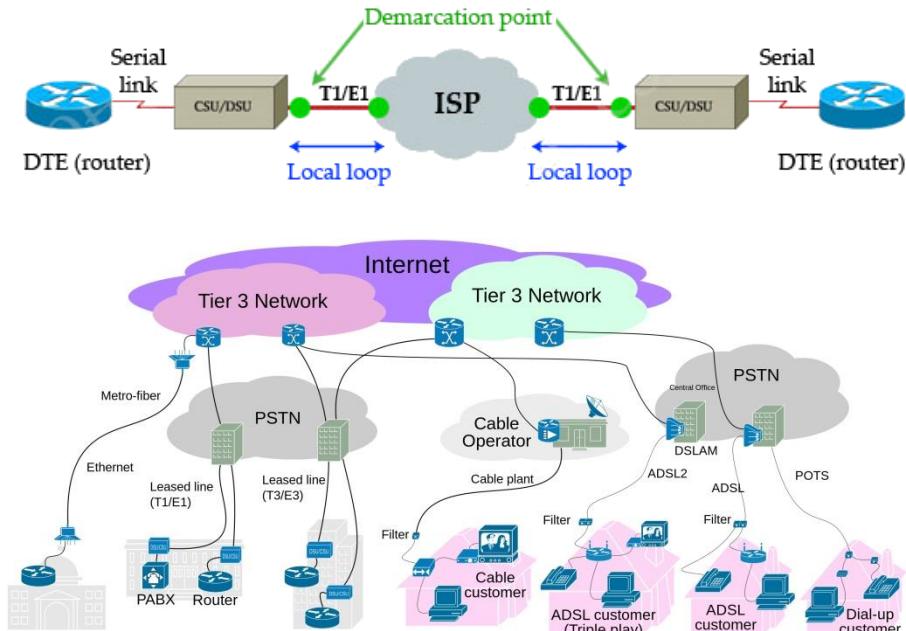
Fiber Optic Communications

Principles of Communications Systems

Internet Communications

- sharing of information, ideas, or simply words over the Internet, which consists of a worldwide string of connected networks that exchanges data through packet switching using the standardized Internet Protocol Suite (TCP/IP)

ISP – Internet Service Provider



Module 2



Digital and Mobile Telephony

Digital and Mobile Telephony

Telephony

- development, application, and deployment of telecommunication services for electronic transmission of voice, fax, or data, between distant parties

Digital Telephony uses computer hardware, software, and computer networks, that perform functions traditionally performed by telephone equipment.

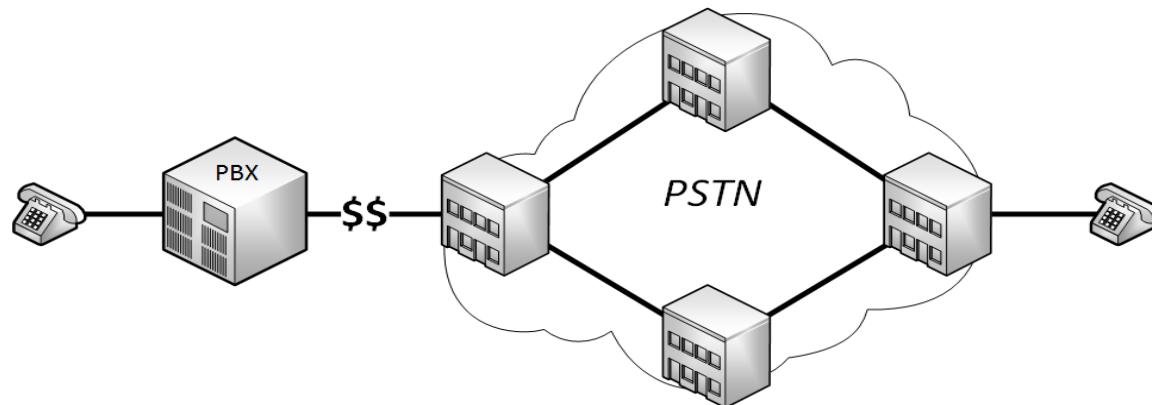


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Digital and Mobile Telephony

Public-Switched Telephone Network (PSTN)

- the world's collection of interconnected voice-oriented public telephone networks
- operated by national, regional, or local telephony operators, providing infrastructure and services for public telecommunication



Digital and Mobile Telephony

Private Branch Exchange (PBX)

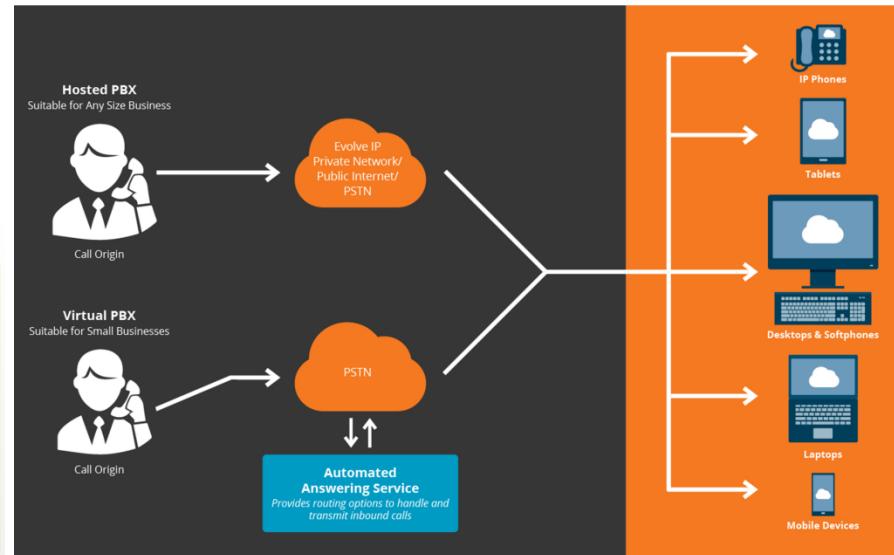
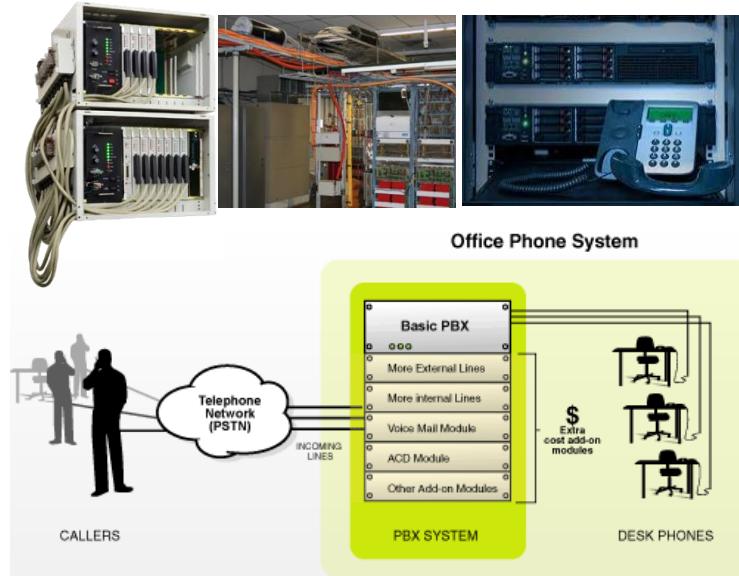
- private telephone network used within a company or organization where the users of the phone system can communicate internally (within their company) and externally (with the outside world), using different communication channels like VoIP, ISDN or analog



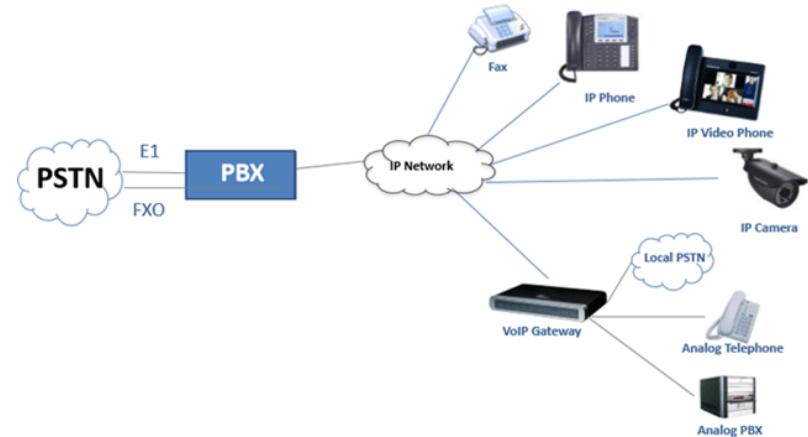
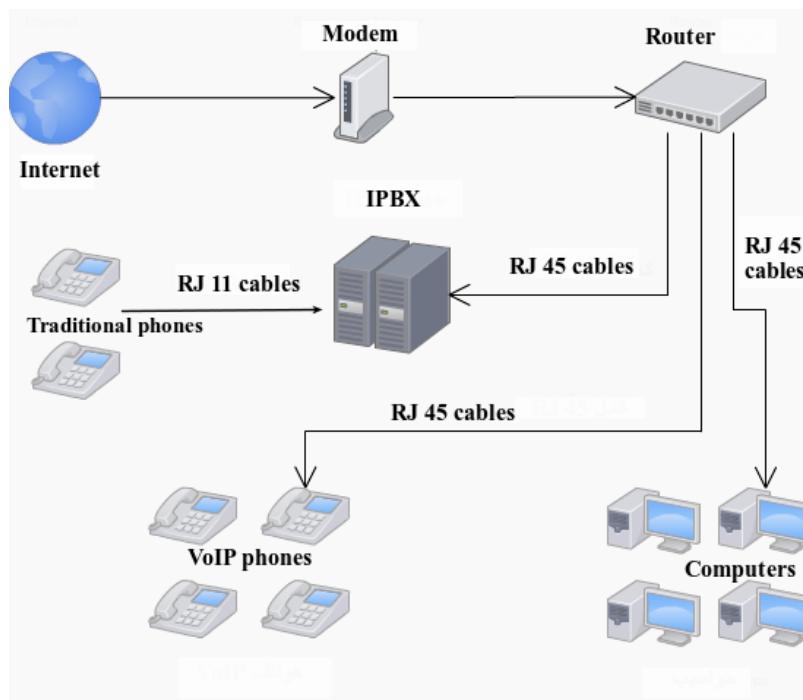
ITEM	PREMISE	HOSTED	Comments
Router	Common Industry Standard	Common Industry Standard	None
Switch/Power adapters	Either/or	Either/or	None
Cabling	Cat5/6, or Cat 3 if using digital devices	Cat5/6	Premise - if infrastructure critical
Key Service Unit/Server	Requires server	None required	Hosted means less equipment
Initial Investment	All Equipment paid upfront, or on lease	Options available for no upfront expense	Advantage-Hosted

Digital and Mobile Telephony

Types of PBX



Digital and Mobile Telephony

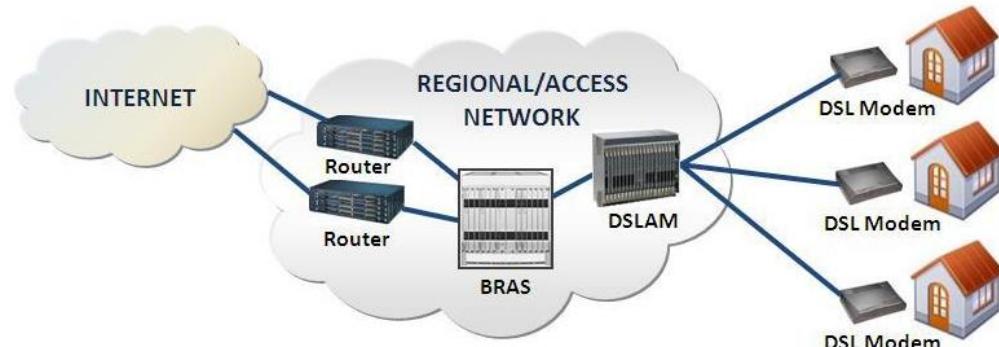


Internet Protocol Private Branch Exchange (IP PBX) is a system that connects telephone extensions to the public switched telephone network (PSTN) and provides internal communication for a business.

Digital and Mobile Telephony

Digital Subscriber Line (DSL)

- technology that uses existing telephone lines to transport high-bandwidth data, such as multimedia and video, to service subscribers
- group of digital technologies that can provide high-speed digital signal transmission over the existing twisted-wire pair in local loops



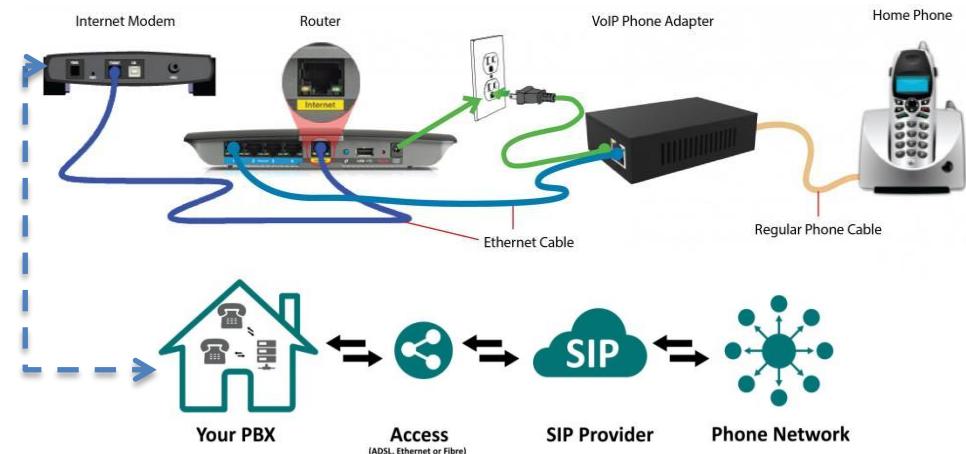
Type	Description	Data Rate Upstream Data Rate	Max Downstream Data Rate	Max Reach	POTS Support
HDSL	High Bit Rate - DSL	1.54Mbps	1.54Mbps	3650mtrs	No
ADSL	Asymmetric - DSL	800Kbps	8Mbps	5500mtrs	Yes
SDSL	Symmetric - DSL	2.3Mbps	2.3Mbps	6700mtrs	No
VDSL	Very High Bit Rate - DSL	16Mbps	52Mbps	1200mtrs	Yes
VDSL2	Very High Bit Rate - DSL (2nd Generation)	100Mbps	100Mbps	<1500mtrs	Yes

Digital and Mobile Telephony

Voice over Internet Protocol (VoIP)

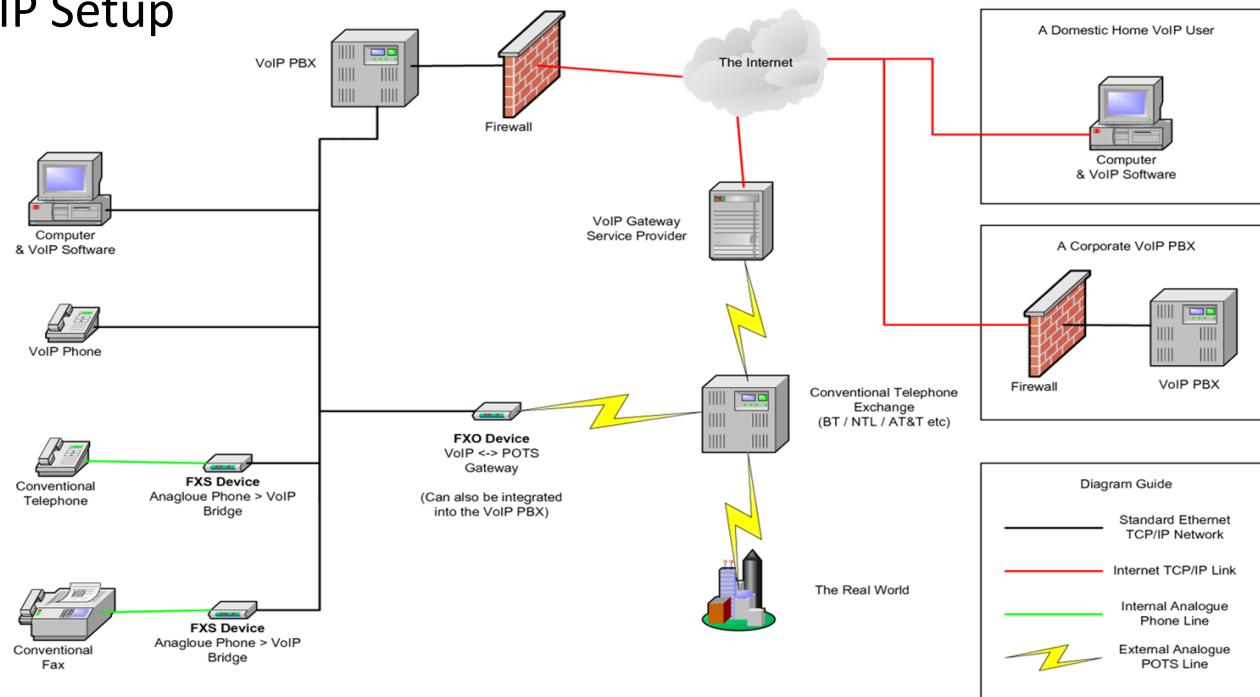
- method and group of technologies for the delivery of voice communications and multimedia sessions over Internet Protocol networks, such as the Internet
- also called ***IP telephony***

Session Initiation Protocol (SIP) is a signaling protocol used for initiating, maintaining, and terminating real-time sessions that include voice, video and messaging applications.



Digital and Mobile Telephony

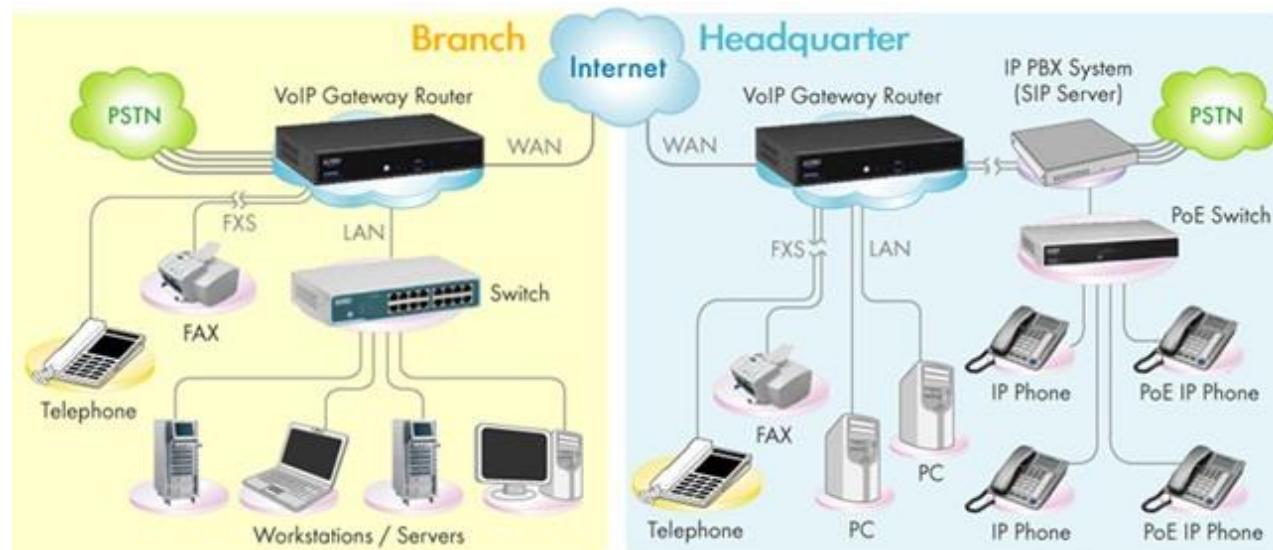
Basic VoIP Setup



Digital and Mobile Telephony

VoIP Gateway

- device that uses Internet Protocols to transmit and receive voice communications (VoIP)



Digital and Mobile Telephony

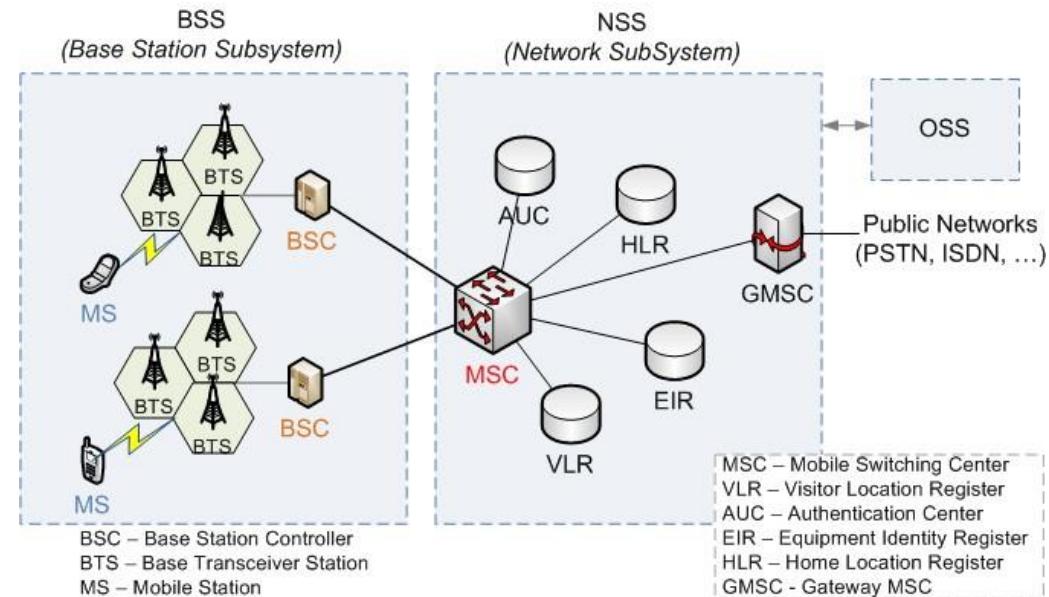
Cisco IP Phone



Digital and Mobile Telephony

Mobile Telephony

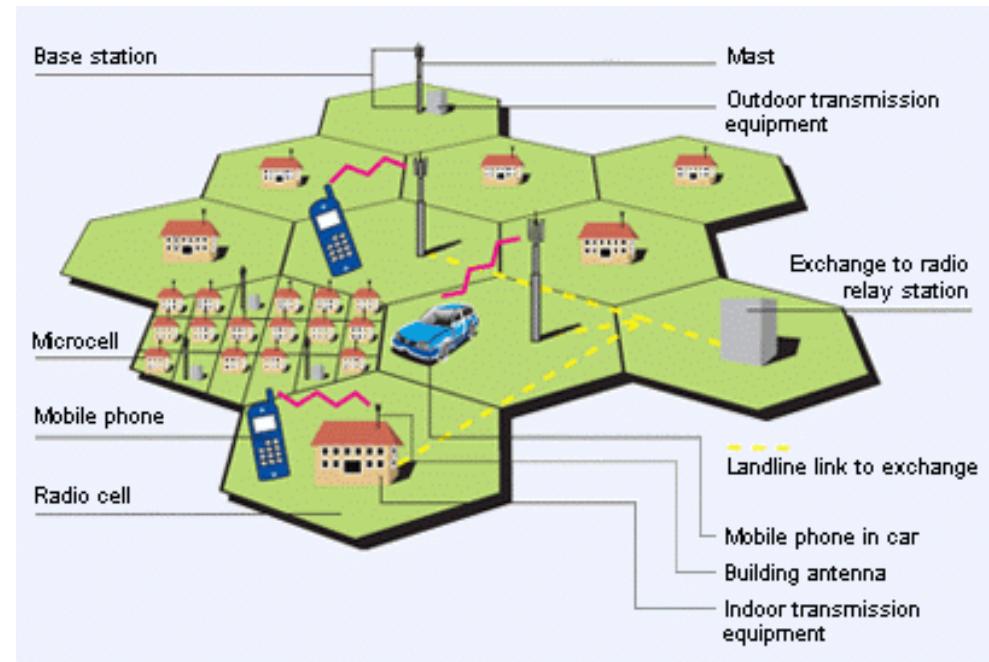
- provision of telephone services to phones which may move around freely rather than stay fixed in one location
- also called *cellular telephony*



Digital and Mobile Telephony

The “Cells”

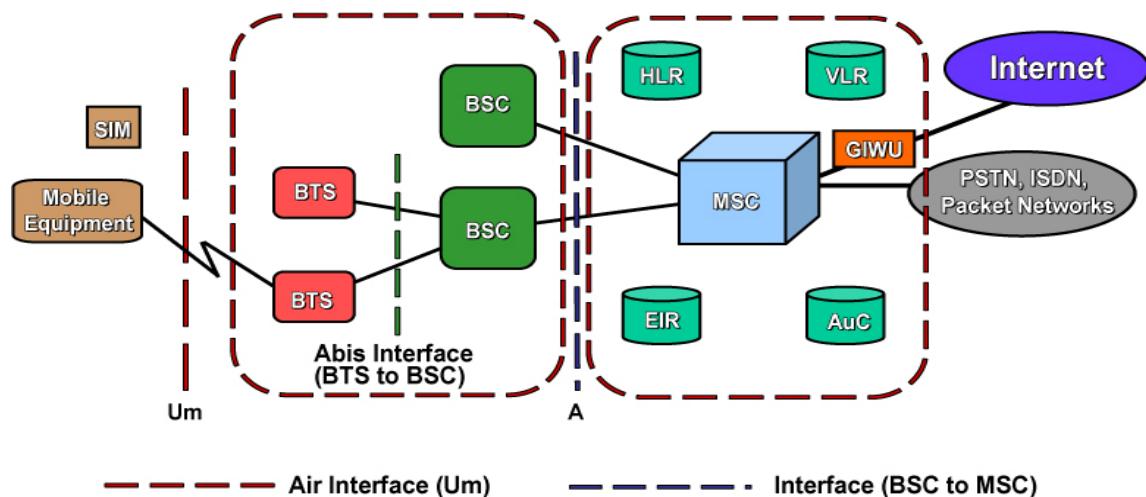
Cellular communication is based on the geographic division of the communication coverage area into *cells*, and within cells. Each cell is allocated a given number of frequencies (or channels) that allow a large number of subscribers to conduct conversations simultaneously



Digital and Mobile Telephony

Global System for Mobile Communications (GSM)

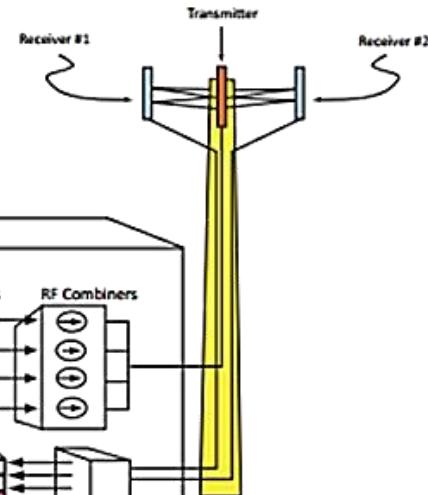
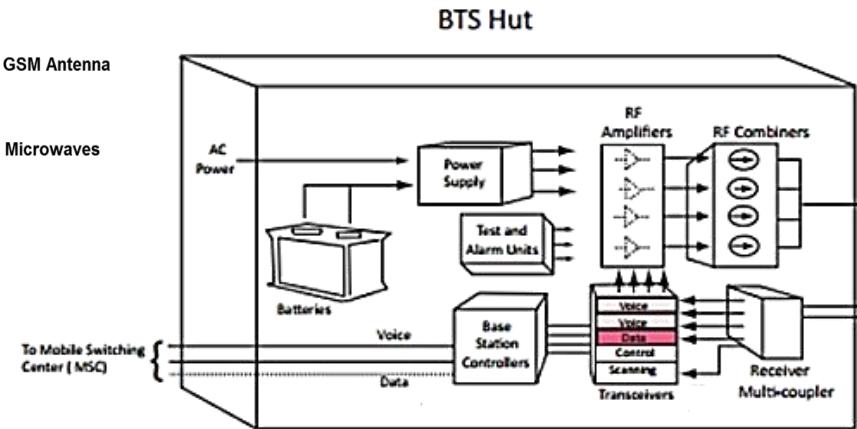
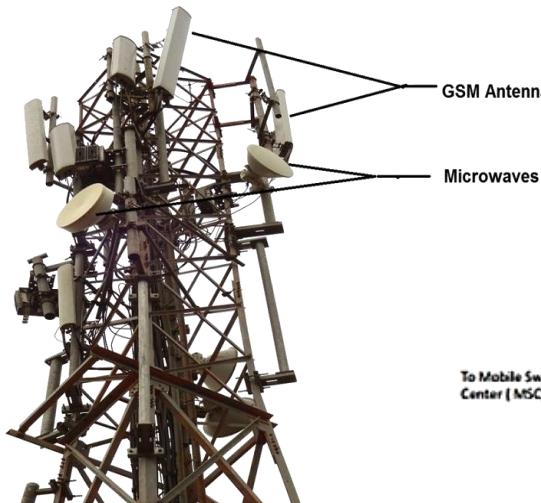
- describes the protocols for second-generation digital cellular networks used by mobile devices such as mobile phones and tablets



Digital and Mobile Telephony

Base Transceiver Station (BTS)

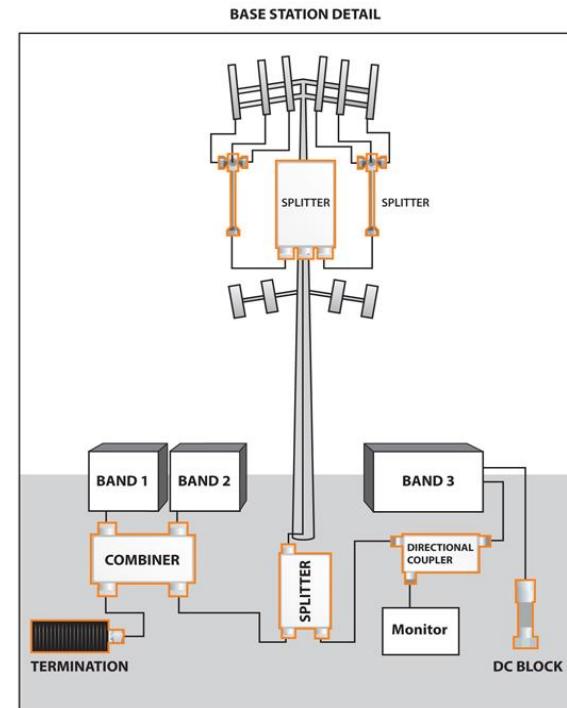
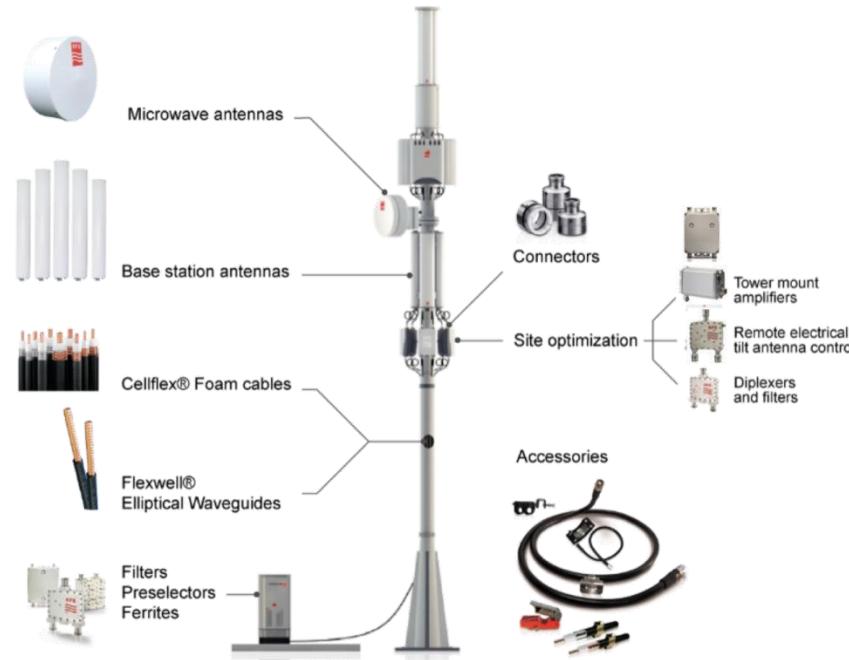
- equipment that facilitates wireless communication between user equipment (UE) and a network



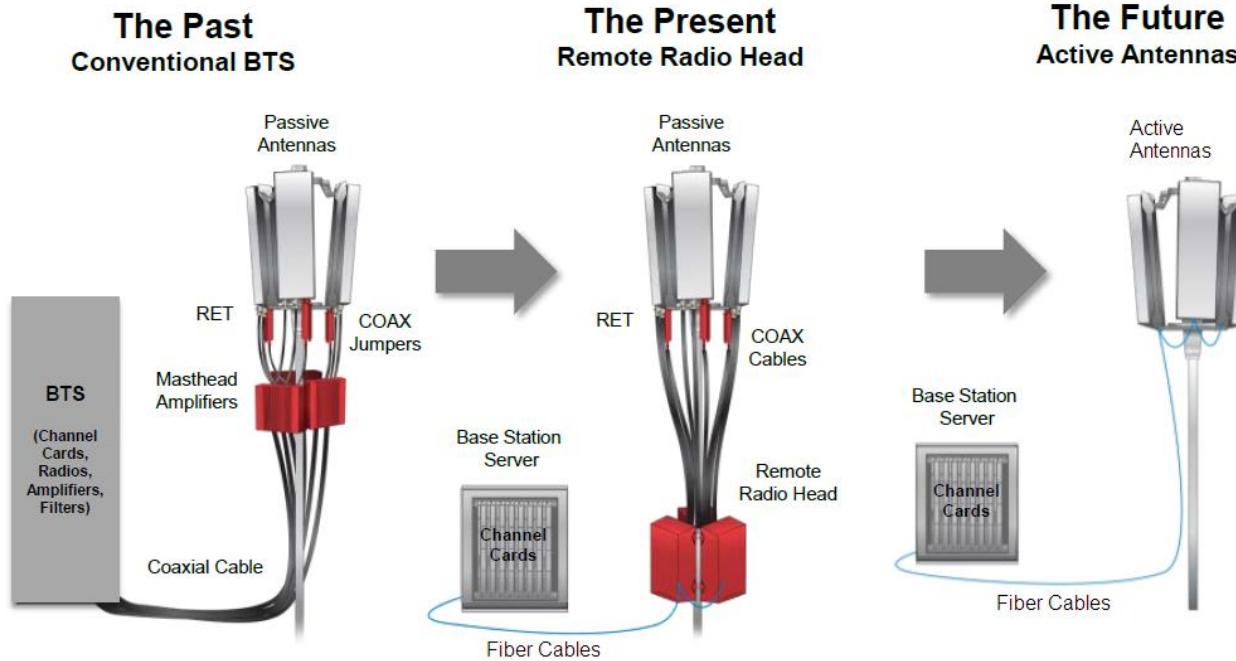
Radio tower and BTS equipment used in a typical cell site location.

Digital and Mobile Telephony

The BTS Antenna

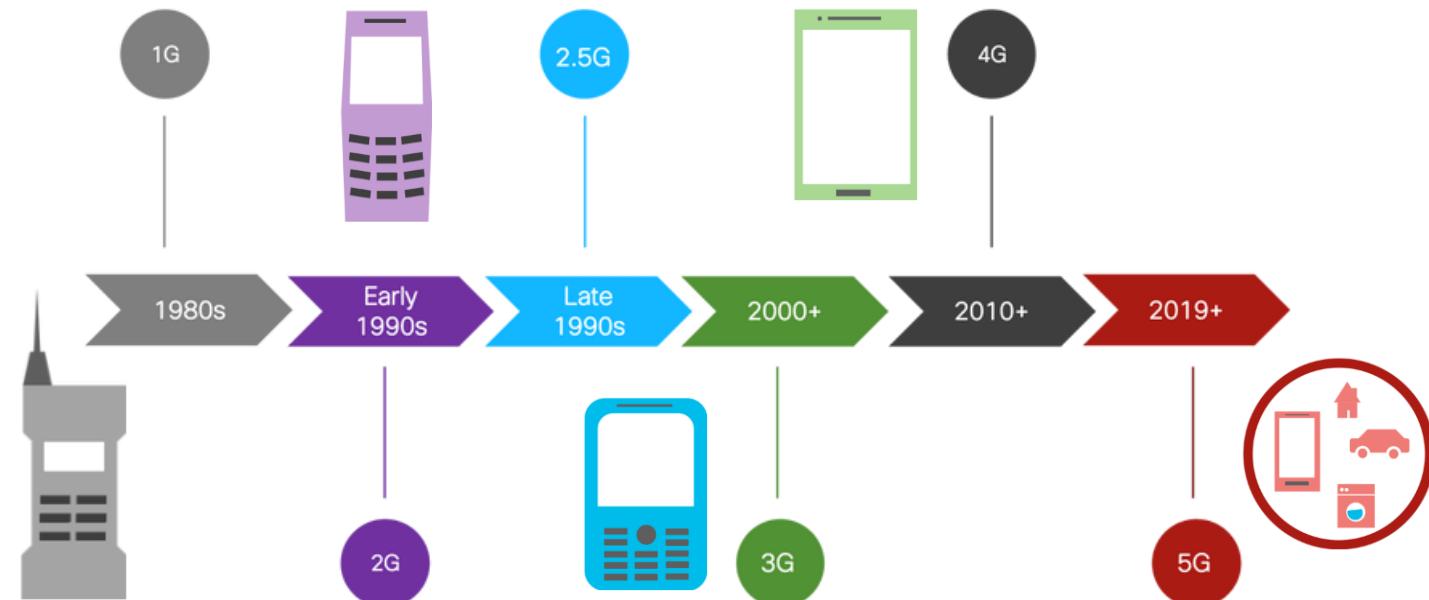


Digital and Mobile Telephony



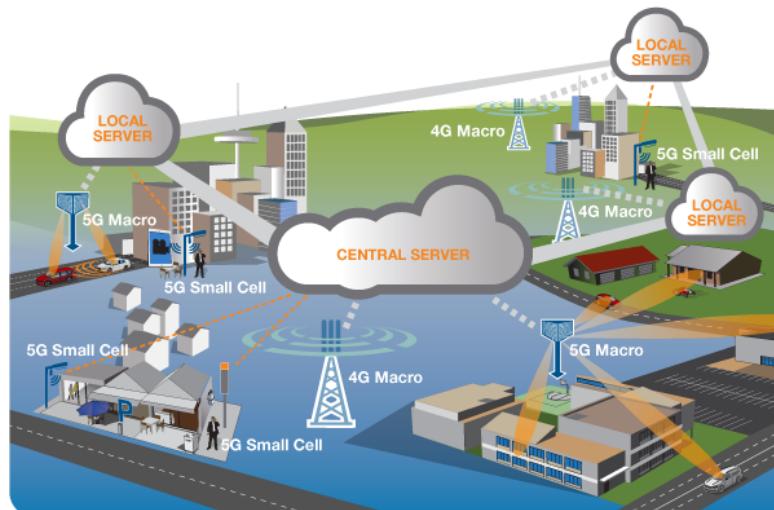
Digital and Mobile Telephony

Evolution of Mobile Technology



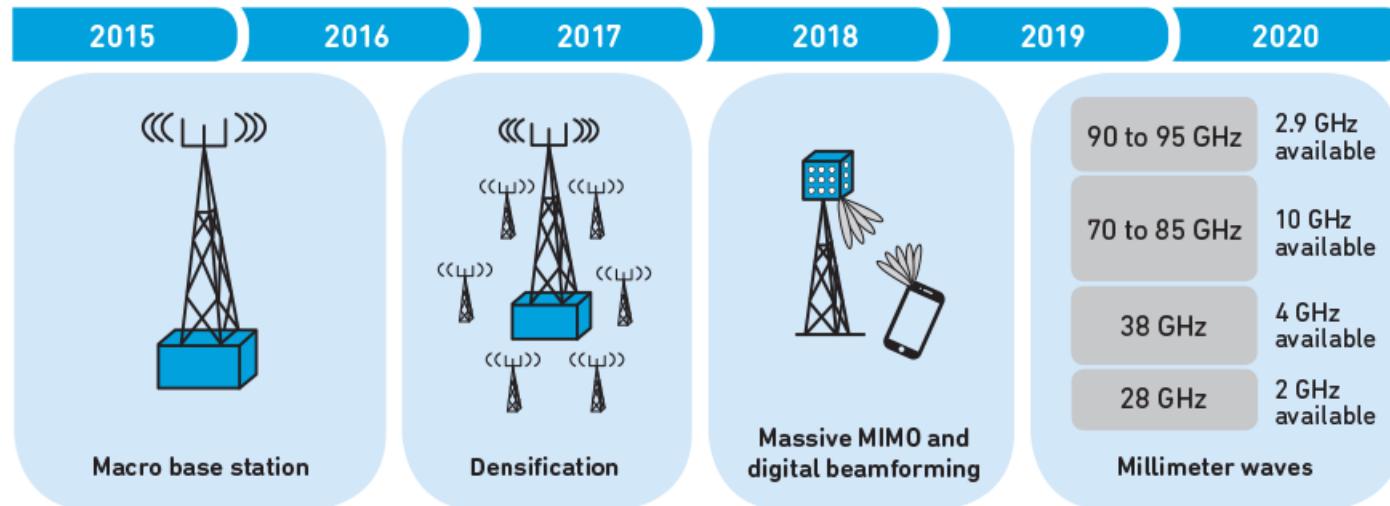
Digital and Mobile Telephony

5G Mobile Technology



Digital and Mobile Telephony

Developments in the 5G Technology



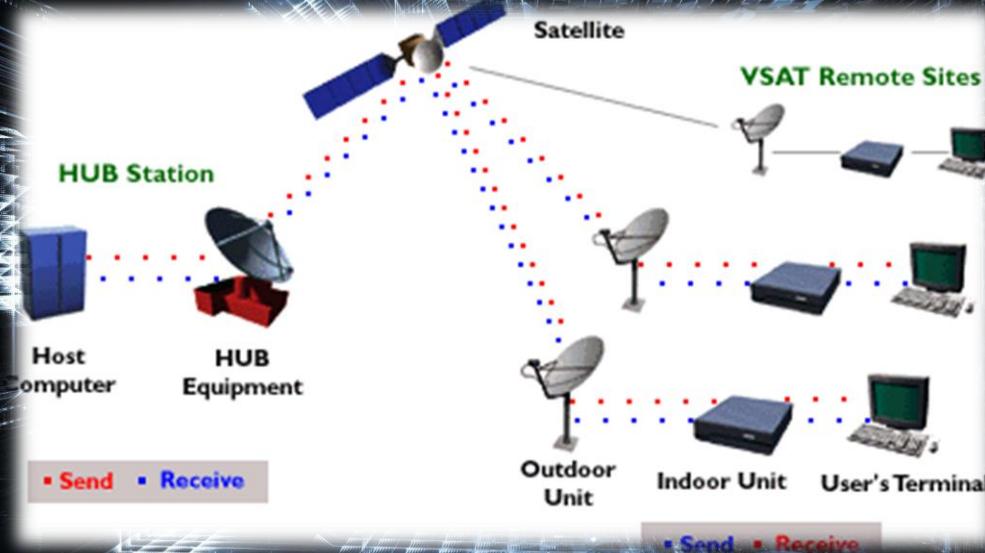
- Increasing frequency beyond 2.7 GHz to 6 GHz
- Increasing bandwidth
- Increasing efficiency

- Small cells
- DAS
- LTE-U

- Up to 6 GHz
- Array antenna

- Ultra-wide bandwidth
- Ultra-high throughput

Module 3

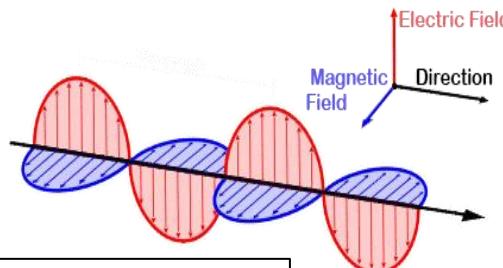


Terrestrial and Satellite Communications

Terrestrial and Satellite Communications

Radio Waves

- electromagnetic (EM) waves best-known for their use in wireless communication technologies, such as TV, mobile phones and radios
- have frequencies as high as 300 gigahertz (GHz) to as low as 30 hertz (Hz)



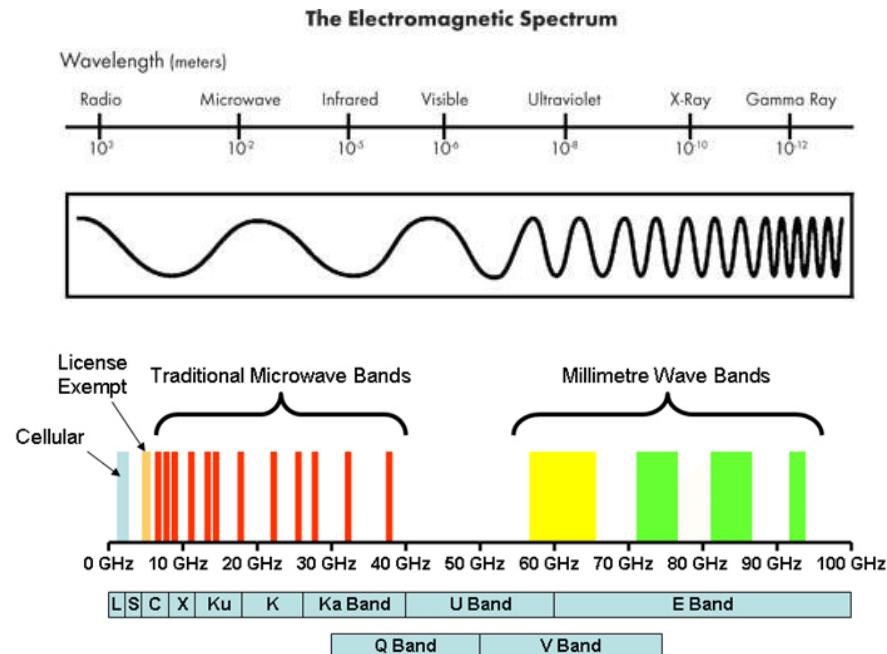
$$\lambda = \frac{c}{f} = \frac{3 \times 10^8 \text{ m/s}}{f}$$

Name	Frequency	Wavelength
Extremely low frequencies (ELFs)	30–300 Hz	10^7 – 10^6 m
Voice frequencies (VFs)	300–3000 Hz	10^6 – 10^5 m
Very low frequencies (VLFs)	3–30 kHz	10^5 – 10^4 m
Low frequencies (LFs)	30–300 kHz	10^4 – 10^3 m
Medium frequencies (MFs)	300 kHz–3 MHz	10^3 – 10^2 m
High frequencies (HFs)	3–30 MHz	10^2 – 10^1 m
Very high frequencies (VHFs)	30–300 MHz	10^1 –1 m
Ultra high frequencies (UHFs)	300 MHz–3 GHz	1 – 10^{-1} m
Super high frequencies (SHFs)	3–30 GHz	10^{-1} – 10^{-2} m
Extremely high frequencies (EHFs)	30–300 GHz	10^{-2} – 10^{-3} m

Terrestrial and Satellite Communications

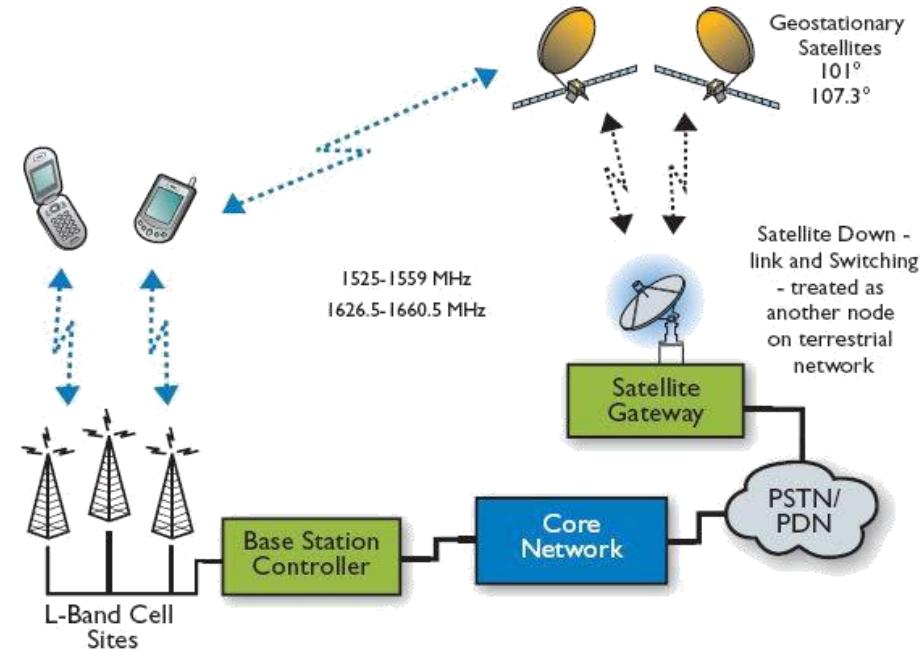
Microwaves

- radio waves with frequencies between 300 MHz (1 m) and 300 GHz (1 mm)
- travel by line-of-sight (LOS); so terrestrial microwave communication links are limited by the visual horizon to about 40 miles (64 km)



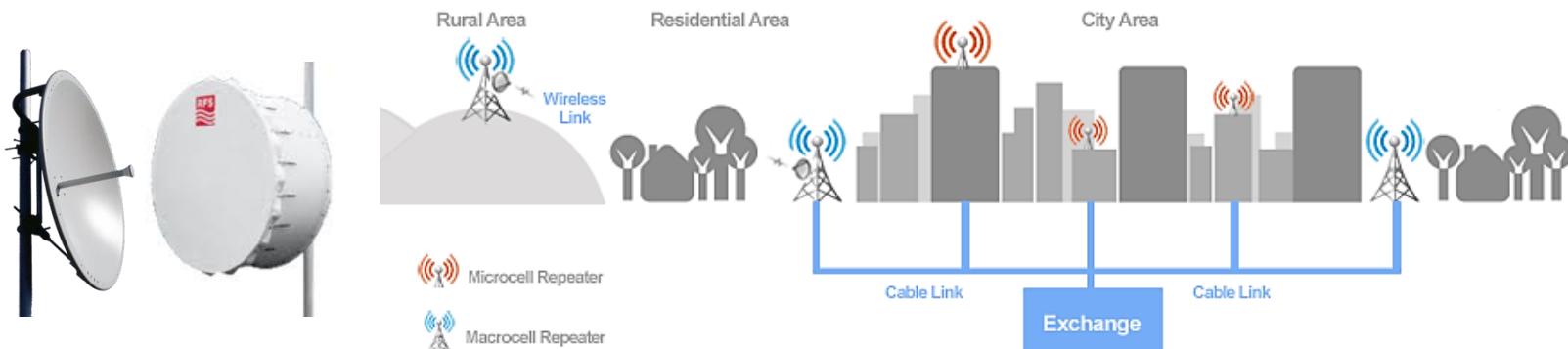
Terrestrial and Satellite Communications

Microwave Transmission is an LOS wireless communication technology that uses high frequency beams of radio waves to provide high speed wireless connections that can send and receive voice, video, and data information.



Terrestrial and Satellite Communications

Microwave Terrestrial Communications (or *point-to-point communication*) is a wireless point-to-point connection between two communication endpoints or nodes. It employs Earth-based transmitters and receivers in the form of telephone relay towers, which are placed every few miles to relay telephone signals cross-country. Transmissions typically use a parabolic antenna that produces a narrow, highly directional signal, which is why LOS between the linked nodes must be maintained.



Terrestrial and Satellite Communications

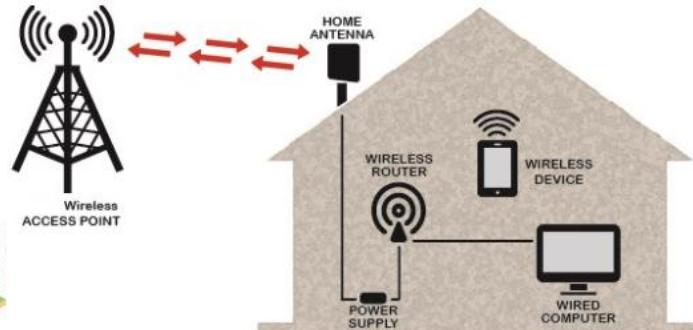
Wireless ISP



Mobile



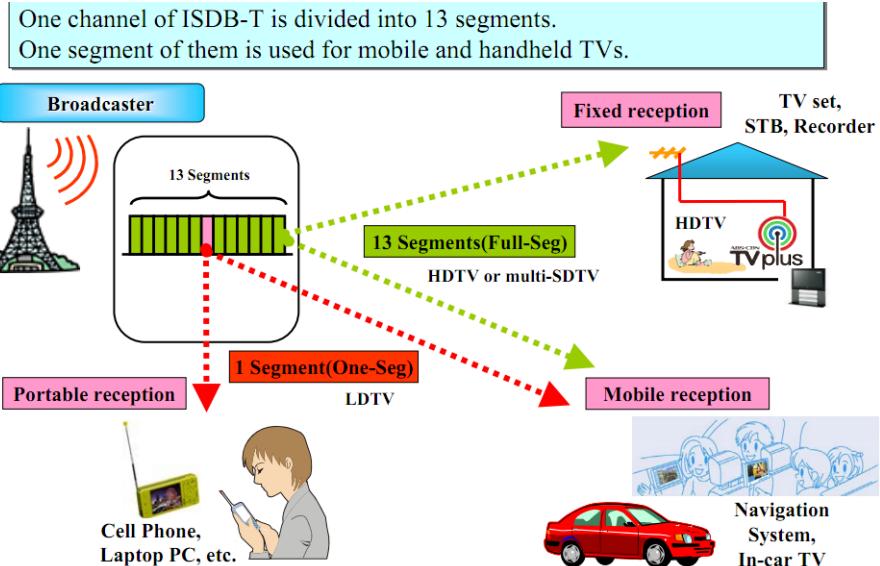
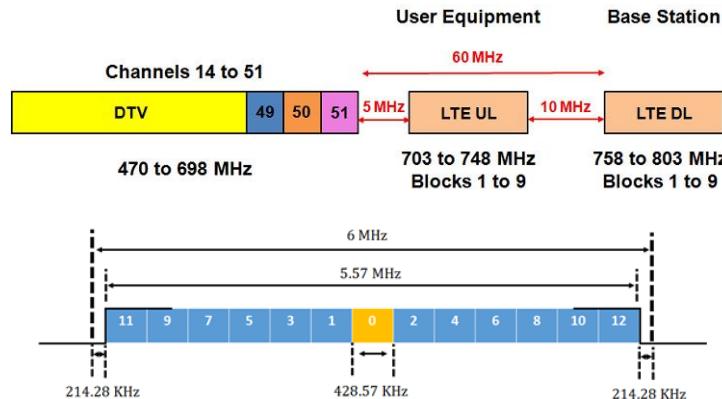
Fixed



<https://www.imoney.ph/articles/broadband-internet-providers-philippines/>

Terrestrial and Satellite Communications

Digital Terrestrial TV (DTTV) Broadcast

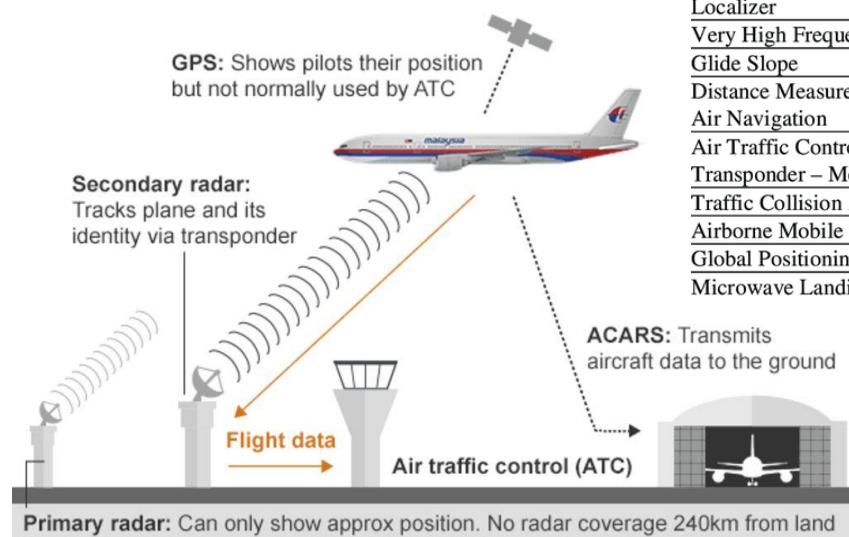


DTTV Standards

- Advanced Television Systems Committee (ATSC) – USA
- Digital Video Broadcast – Terrestrial (DVB-T) – Europe
- Integrated Services Digital Broadcasting – Terrestrial (ISDB-T) – Japan → Used in the Philippines

Terrestrial and Satellite Communications

Aircraft Navigation Systems



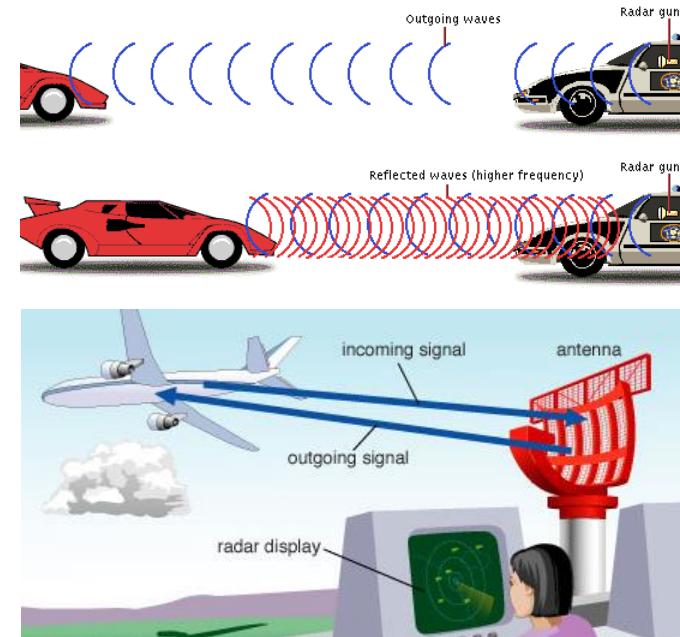
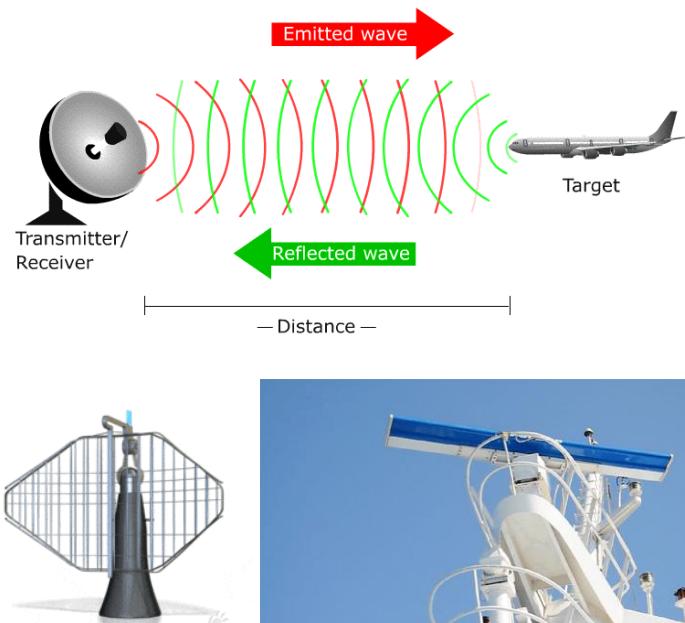
Aircraft Systems	Abbreviation	Receive Frequency Range (MHz)
HF Communications	HF	2.850-23.350
Marker Beacon	MB	74.8 -75.2
VHF Omni-Range	VOR	108 – 117.95
Localizer	LOC	108.1-111.95
Very High Frequency Communication	VHF	118 - 137
Glide Slope	GS	328.6 –335.4
Distance Measurement Equipment/ Tactical Air Navigation	DME/TACAN	962 - 1213
Air Traffic Control	ATC Mode S	1030
Transponder – Mode S		
Traffic Collision Avoidance System	TCAS	1090
Airborne Mobile Satellite Service	AMSS	1530 –1559
Global Positioning System	GPS	1575.42 +/- 2
Microwave Landing System	MLS	5031 - 5090.7

Main Navigational Aids:

- Instrument Landing System (ILS)
- Air Traffic Management (ATM)
- Radar and Pilot Position Reports
- Voice Communication

Terrestrial and Satellite Communications

Radio Detection and Ranging (Radar) Systems



Terrestrial and Satellite Communications



Slotted-Waveguide Radar Antenna



Parabolic Radar Antenna

Terrestrial and Satellite Communications

Standard Radar Frequencies

Band	Frequency (GHz)
L Band	1-2
S Band	2-4
C Band	4-8
X Band	8-12
KU Band	12-18
K Band	18-27
KA Band	27-40
V Band	40-75
W Band	75-110

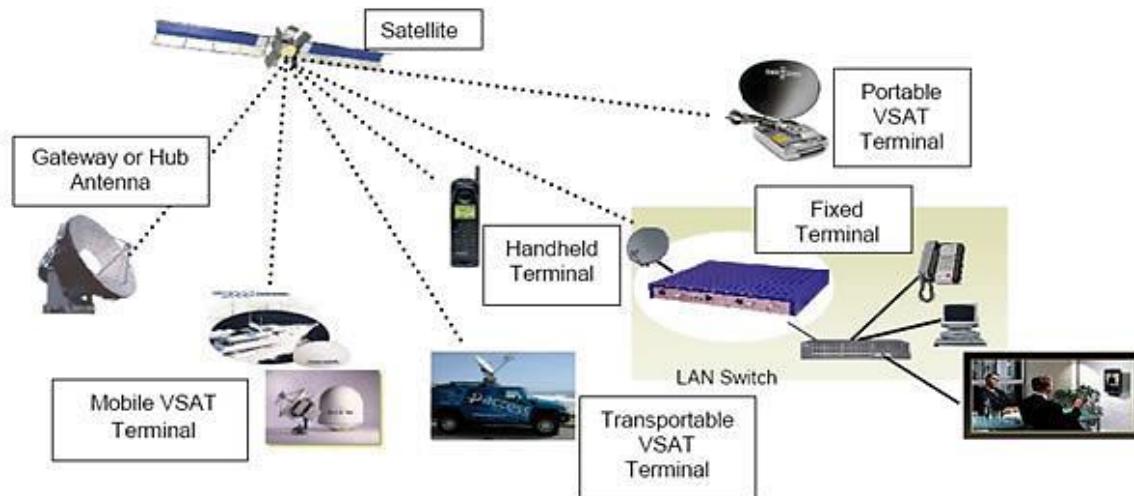
E band

E band Fixed Point to Point	71-76
Automotive radar	77-81
E band Fixed Point to Point	81-86
E band Fixed Point to Point	92-95



Terrestrial and Satellite Communications

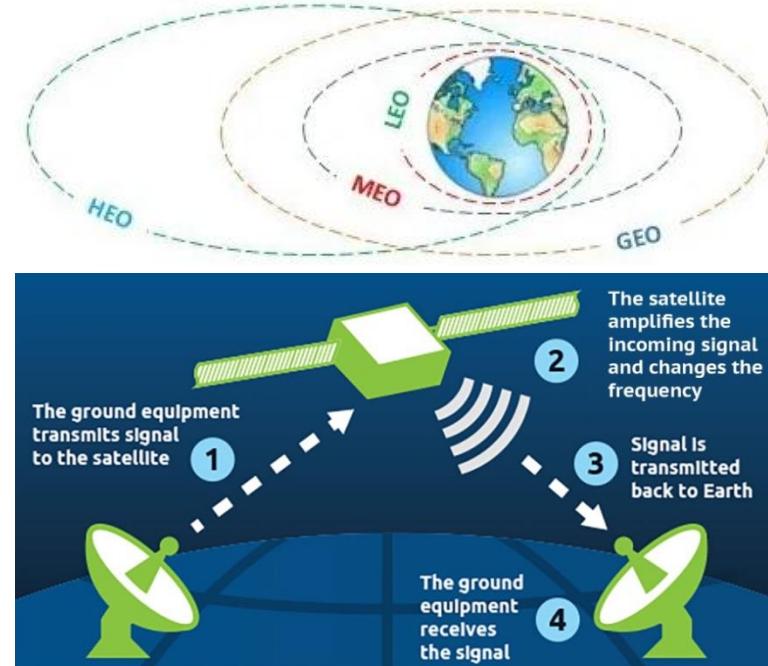
Satellite Communications is the use of artificial satellites to provide communication links between various points on Earth. Telecommunication satellites are designed to relay several, or more usually many, signals simultaneously.



Terrestrial and Satellite Communications

How Satellite Communication Works

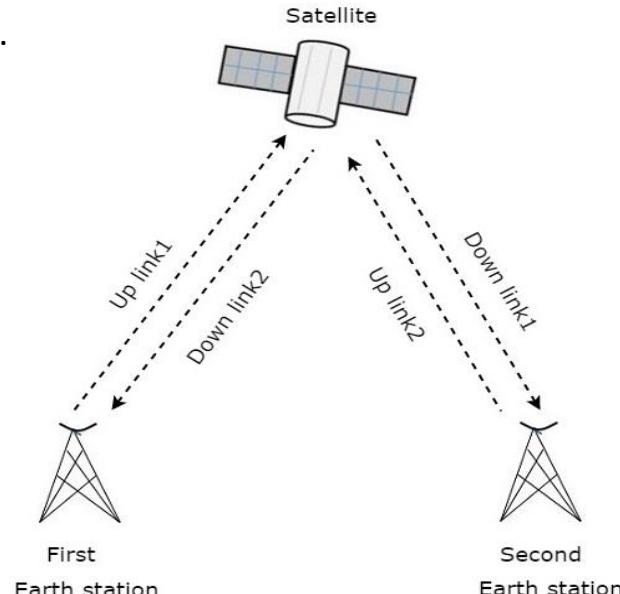
Parameter	LEO	MEO	GEO
Satellite Height	500-1500 km	5000-12000 km	35,800 km
Orbital Period	10-40 minutes	2-8 hours	24 hours
Number of Satellites	40-80	8-20	3
Satellite Life	Short	Long	Long
Number of Handoffs	High	Low	Least(None)
Gateway Cost	Very Expensive	Expensive	Cheap
Propagation Loss	Least	High	Highest



Terrestrial and Satellite Communications

Advantages of Satellite

- ✓ Coverage area is very high.
- ✓ Transmission cost is independent of the coverage area.
- ✓ Higher bandwidths are possible.

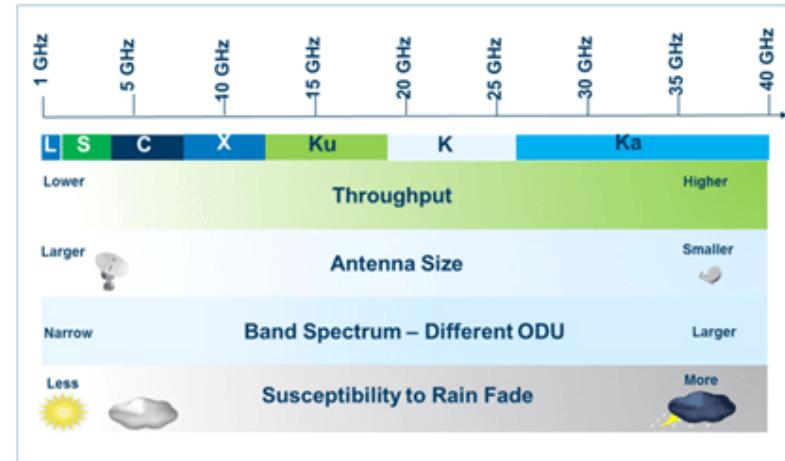
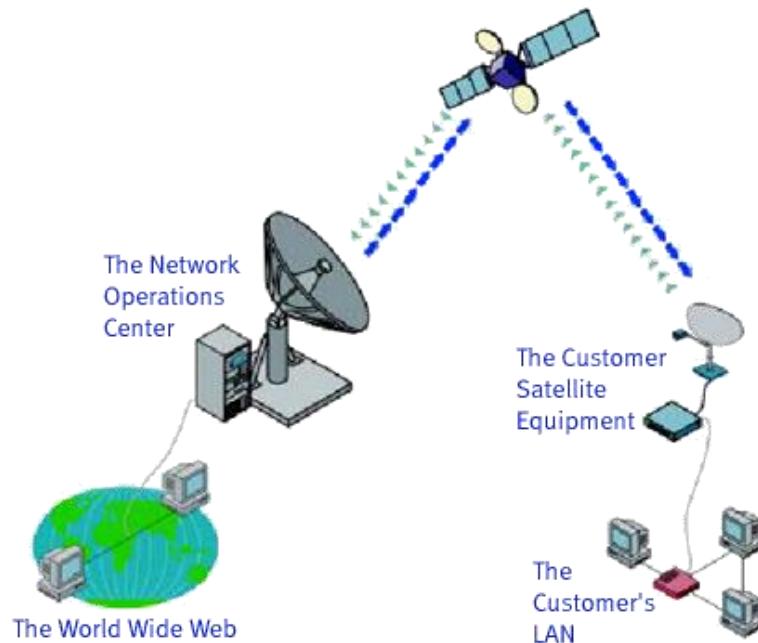


Disadvantages of Satellite

- ✓ Launching satellites into orbits is a costly process.
- ✓ Bandwidths are gradually used up.
- ✓ High propagation delay.

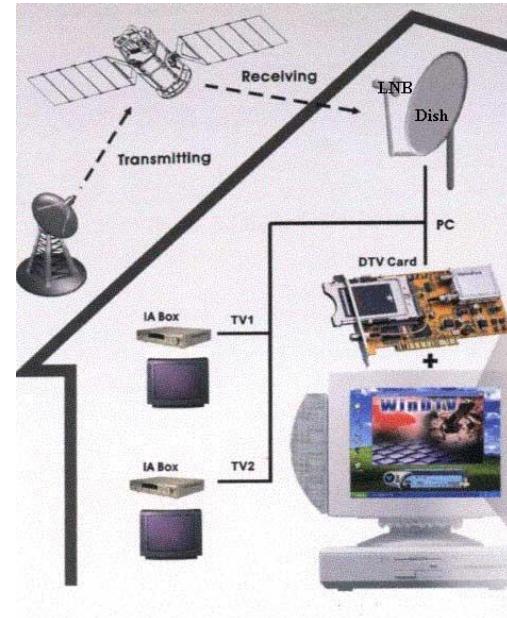
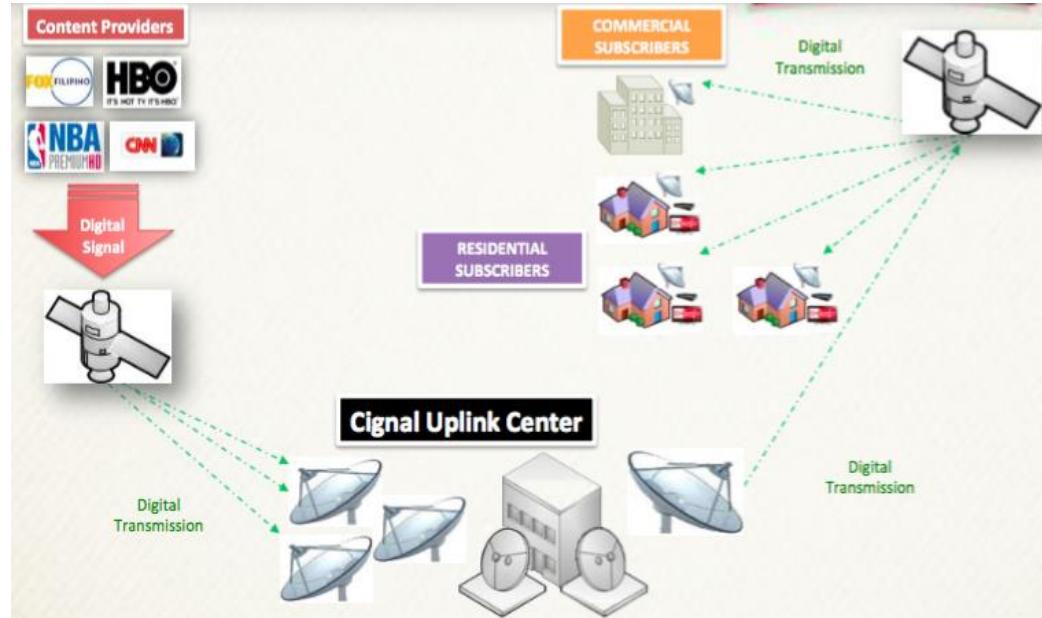
Terrestrial and Satellite Communications

Satellite ISP



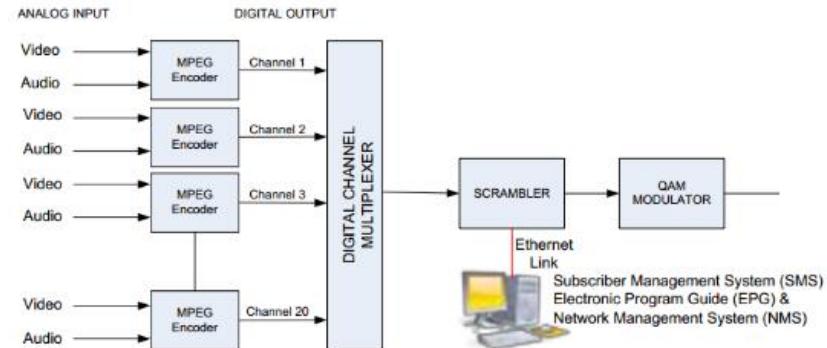
Terrestrial and Satellite Communications

Satellite TV Broadcast (or Direct Broadcast TV, DBT)



Terrestrial and Satellite Communications

IP and Satellite Streaming



Band Designation	Deep Space Bands (for spacecraft greater than 2 million km from Earth)		Near Earth Bands (for spacecraft less than 2 million km from Earth)	
	Uplink (Earth to space)	Downlink (space to Earth)	Uplink (Earth to space)	Downlink (space to Earth)
S-band	2110–2120	2290–2300	2025–2110	2200–2290
X-band	7145–7190	8400–8450	7190–7235	8450–8500
K-band	*	*	*	25500–27000
Ka-band	34200–34700	31800–32300	*	*

* No allocation or not supported by the DSN.

Terrestrial and Satellite Communications

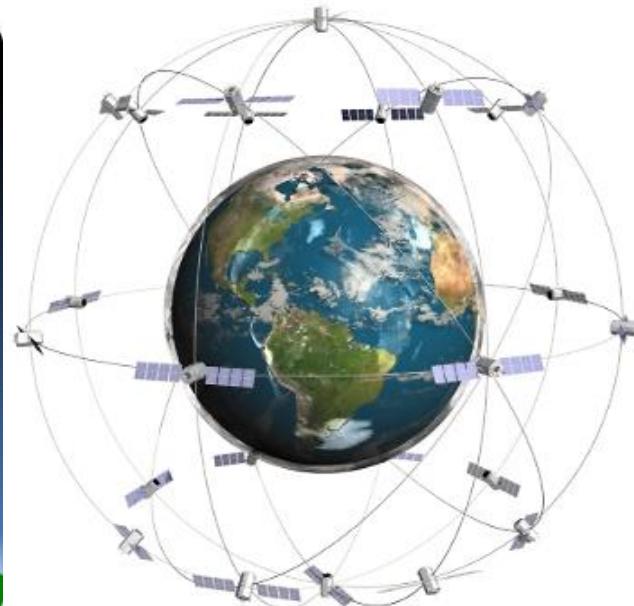
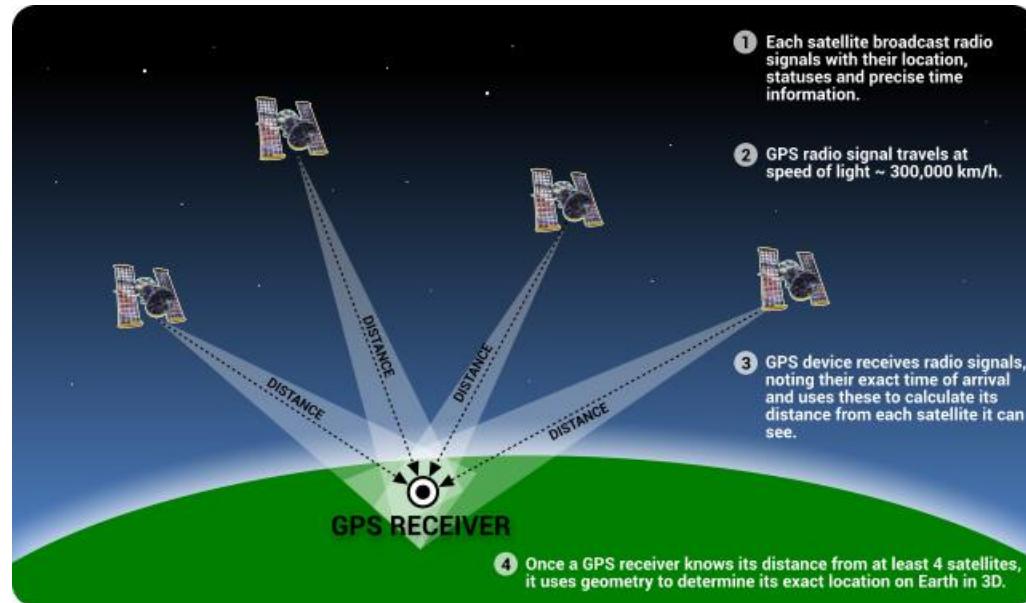
Global Positioning System (GPS) is a US-owned utility that provides users with positioning, navigation, and timing (PNT) services. This system consists of three segments: the space segment, the control segment, and the user segment.

System	Frequency (MHz)	Max. Pout (dBm)	Power at RX antenna input (dBm)	Modulation
GSM850	824 – 849	33 27	18 12	GMSK EDGE
CDMA	824 – 849	25	10	QPSK
EGSM900	880 – 915	33 27	18 12	GMSK EDGE
DCS1800	1710 – 1785	30 26	15 13	GMSK EDGE
PCS1900	1850 – 1910	30 26	15 11	GMSK EDGE
WCDMA FDD	698 – 716	24	9	QPSK
WCDMA FDD	776 – 798	24	9	QPSK
WCDMA FDD	824 – 849	24	9	QPSK
WCDMA FDD	880 – 915	24	9	QPSK
WCDMA FDD	1710 – 1785	24	9	QPSK
WCDMA FDD	1850 – 1910	24	9	QPSK
WCDMA FDD	1920 – 1980	24	9	QPSK
WCDMA FDD	2500 – 2570	24	9	QPSK
Bluetooth	2402 – 2480	10	-5	various
Wi-Fi 802.11b/g	2412 – 2472	18	3	various



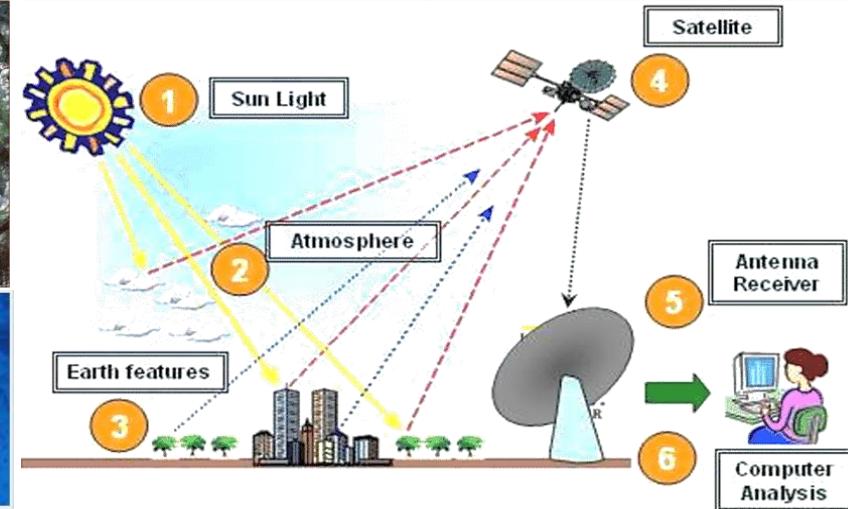
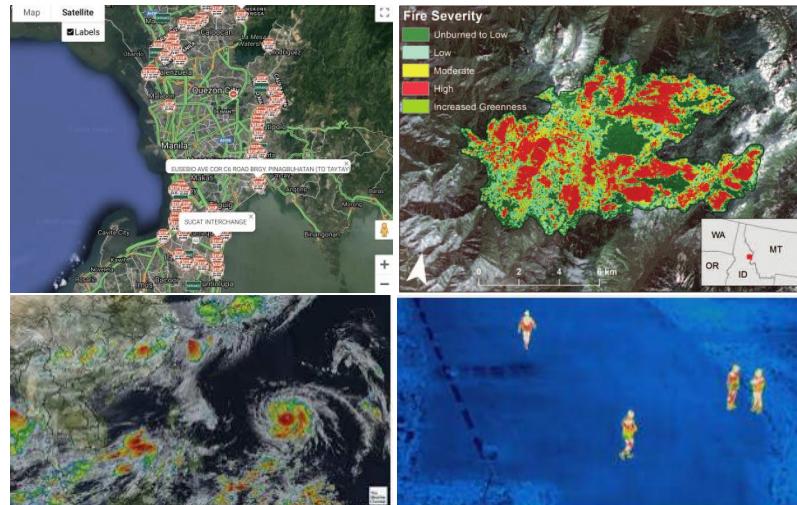
Terrestrial and Satellite Communications

How GPS Works



Terrestrial and Satellite Communications

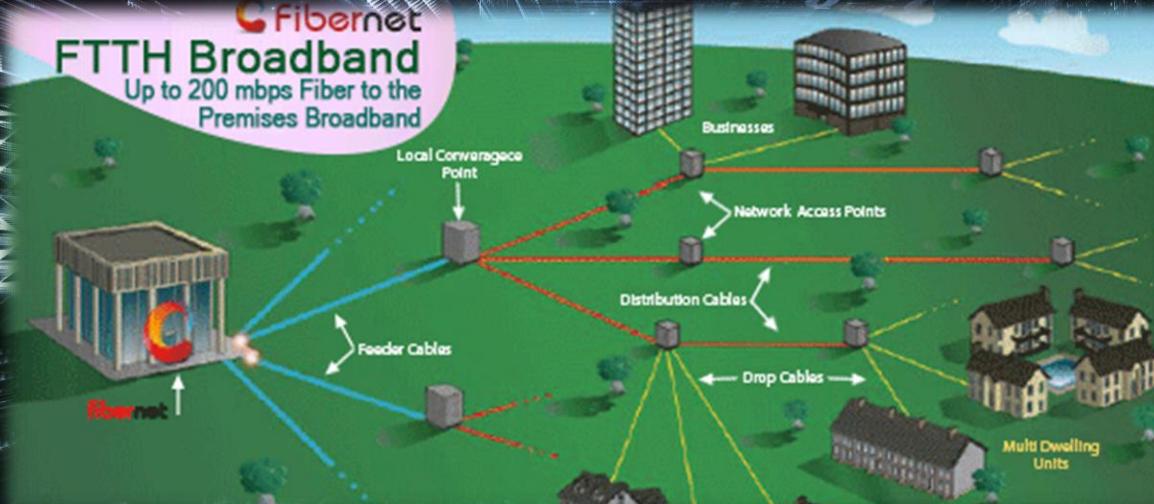
Satellite Imagery and Remote Sensing Data



Telemetry is the collection of measurements or other data at remote points and their automatic transmission to receiving equipment for monitoring

Module 4

Fibernet
FTTH Broadband
Up to 200 mbps Fiber to the
Premises Broadband

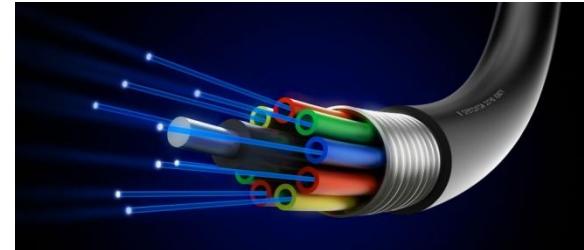
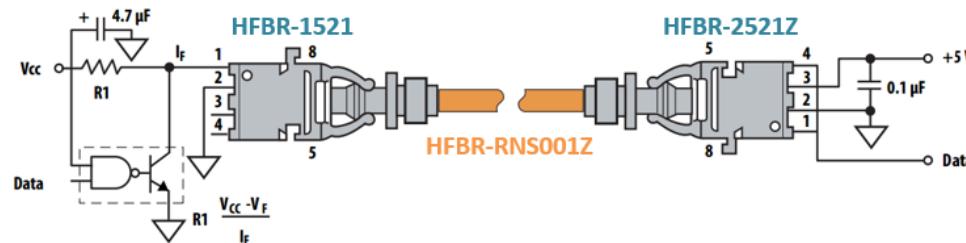


Fiber Optic Systems and Technologies

Fiber Optic Systems and Technologies

Fiber Optic Cable (FOC or OFC)

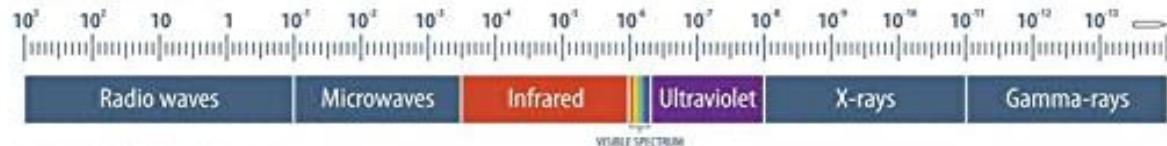
- high-speed data transmission medium consisting one or more strands of glass, each only slightly thicker than a human hair
- can support data transmissions rated at 10 Gbps, 40 Gbps, and 100 Gbps



Fiber Optic Systems and Technologies

The Visible Light Spectrum

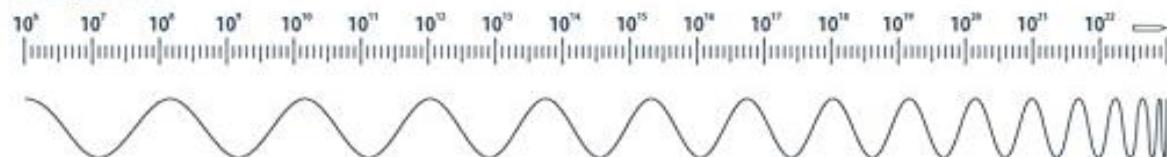
WAVELENGTHS



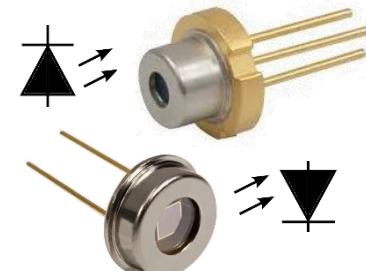
VISIBLE SPECTRUM



FREQUENCY

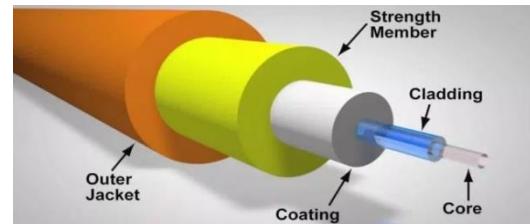
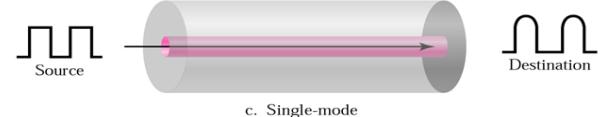
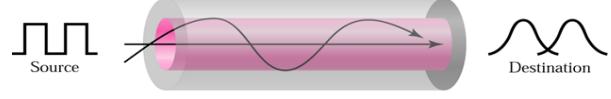
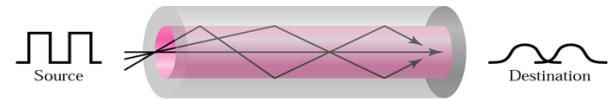
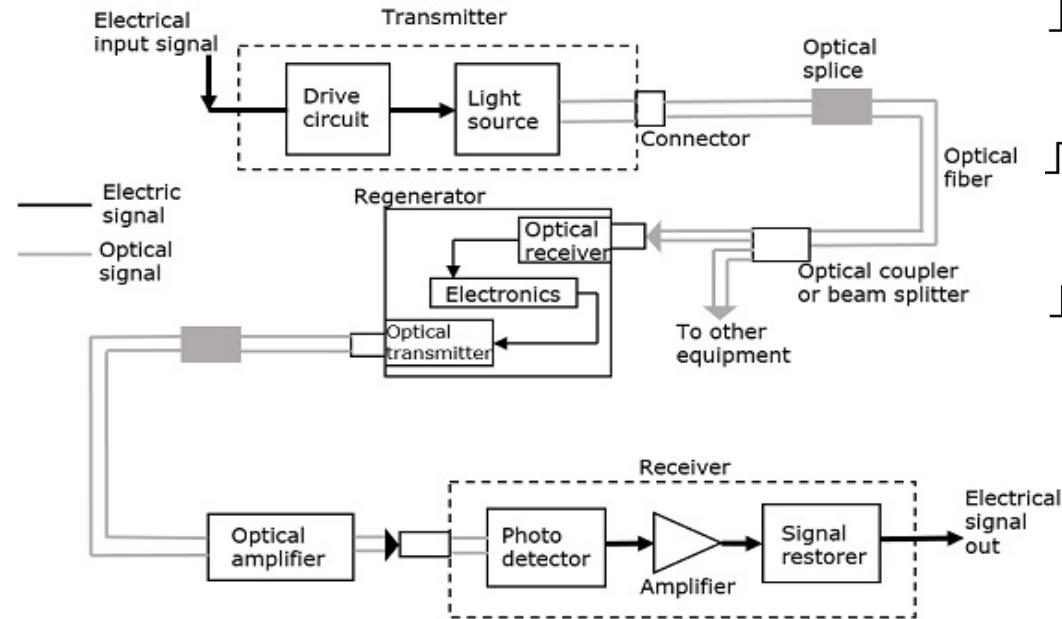


Laser diode (LD) module converts electronic signal into optical intensity signal for FOC transmission while **photodiode (PD)** module converts the transmitted light signal back into electronic signal.



Fiber Optic Systems and Technologies

How Fiber Optics Work



Fiber Optic Systems and Technologies

Physical Advantages of FOC

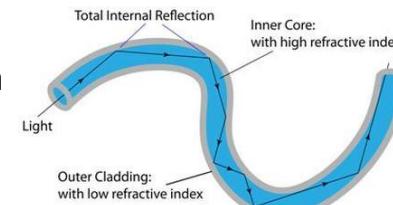
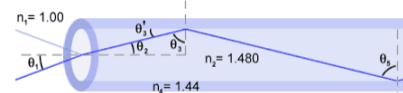
- ✓ much higher capacity and lighter weight
- ✓ no spark hazards
- ✓ more flexible and corrosion resistant
- ✓ raw material is cheaper
- ✓ lasts longer

Functional Advantages of FOC

- ✓ higher bandwidth and amount of data
- ✓ very low power loss
- ✓ provides high transmission security
- ✓ immune to interferences and noise

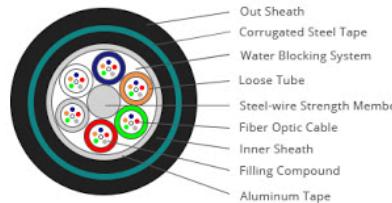
Physical Disadvantages of FOC

- ✓ fragile if not enclosed in a plastic sheath
- ✓ high installation cost
- ✓ no. of repeaters increases with distance



Fiber Optic Systems and Technologies

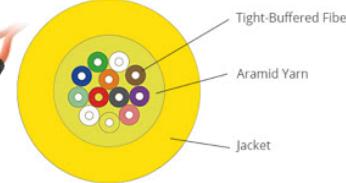
Classifications of FOC



Feeder Cable



Patch Cord



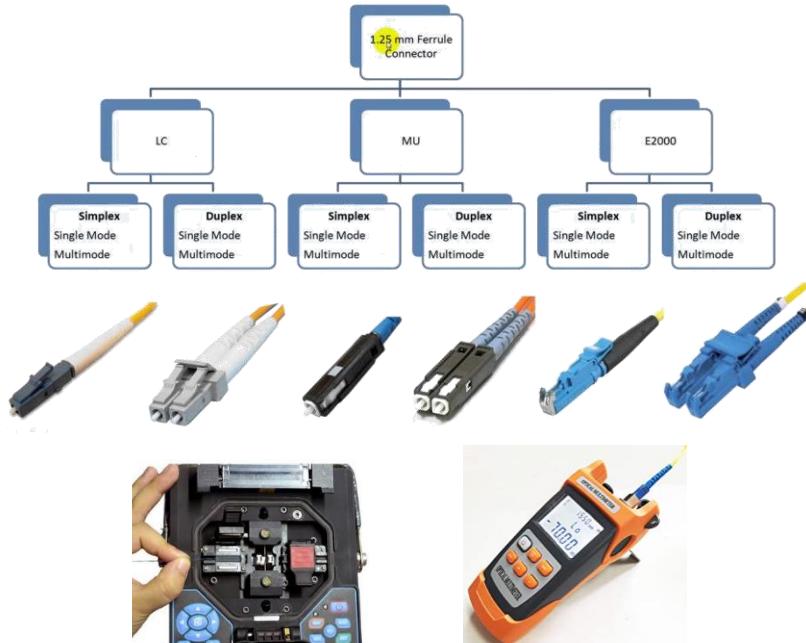
Distribution Cable



Pigtail

Fiber Optic Systems and Technologies

FOC Connectors



Fiber Connector Styles			
	ST Connector A slotted bayonet type connector. This connector is one of the most popular styles.		SC Connector A push/pull type connector. This connector has emerged as one of the most popular styles.
	FC Connector A slotted screw-on type connector. This connector is popular in singlemode applications.		SMA Connector A screw-on type connector. This connector is waning in popularity.
	FDDI Connector A push/pull type dual connector. This connector is one of the more popular styles.		Mini-BNC Connector A bayonet style connector using the traditional BNC connection method.
	Biconic Connector A screw-on style connector. This connector is almost obsolete.		MT-RJ Connector A new RJ style housing fiber connector with two fiber capability.
	ST Feedthru A slotted bayonet type feedthru. ST connectors are one of the most popular styles.		SC Feedthru A push/pull type feedthru. SC connectors are popular in both singlemode and multimode applications.
	FDDI Feedthru A push/pull type feedthru. FDDI connectors are popular in both singlemode and multimode applications.		FC Feedthru A slotted screw-on type feedthru. FC connectors are popular in singlemode applications.

Fiber Optic Systems and Technologies

Key Components of an Optical Network



Optical Line Termination (OLT)



Optical Network Termination (ONT) /
Optical Network Unit (ONU)



Optical Distribution Frame (ODF)



Erbium-Doped Fiber
Amplifier (EDFA)



Coupler



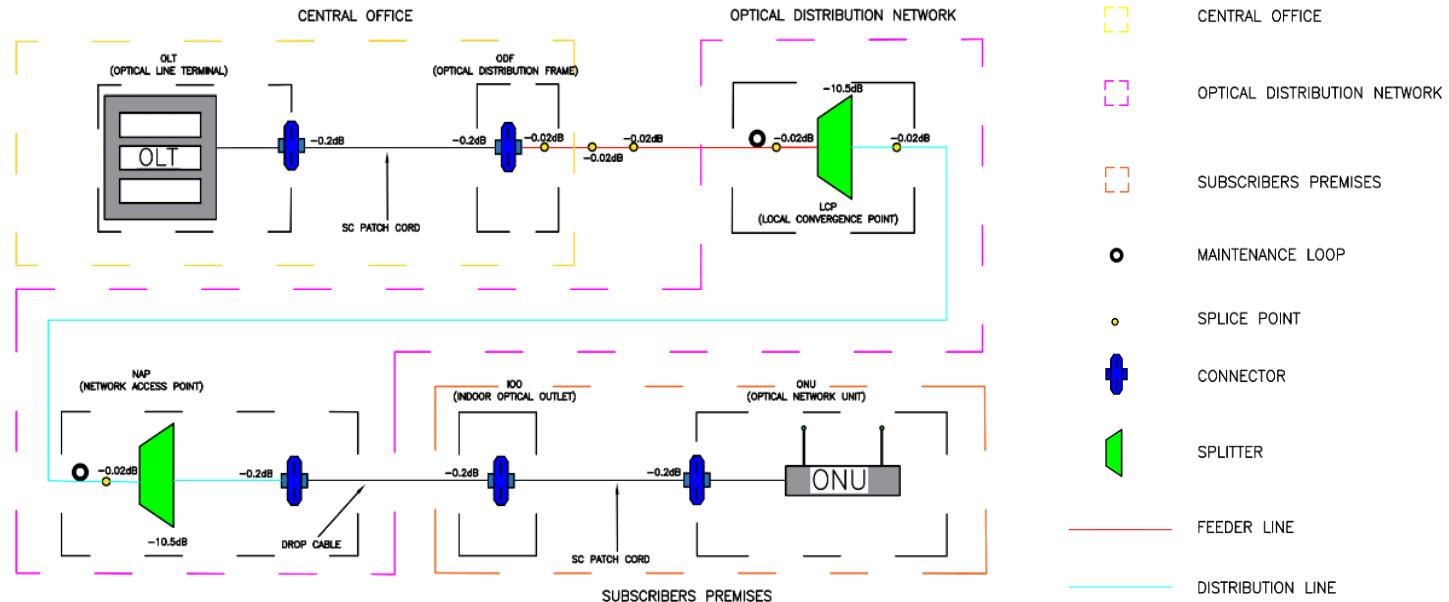
Local Convergence Point (LCP)
Splitter



Network Access Point (NAP)
Splitter

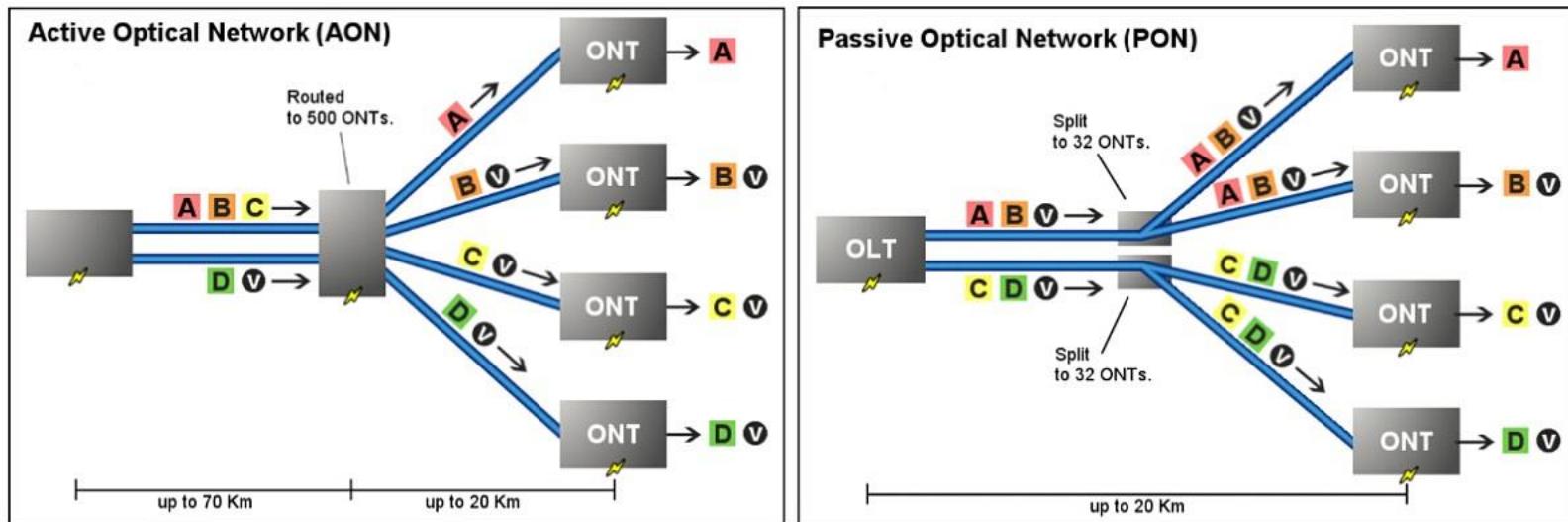
Fiber Optic Systems and Technologies

Sample Optical Network Design



Fiber Optic Systems and Technologies

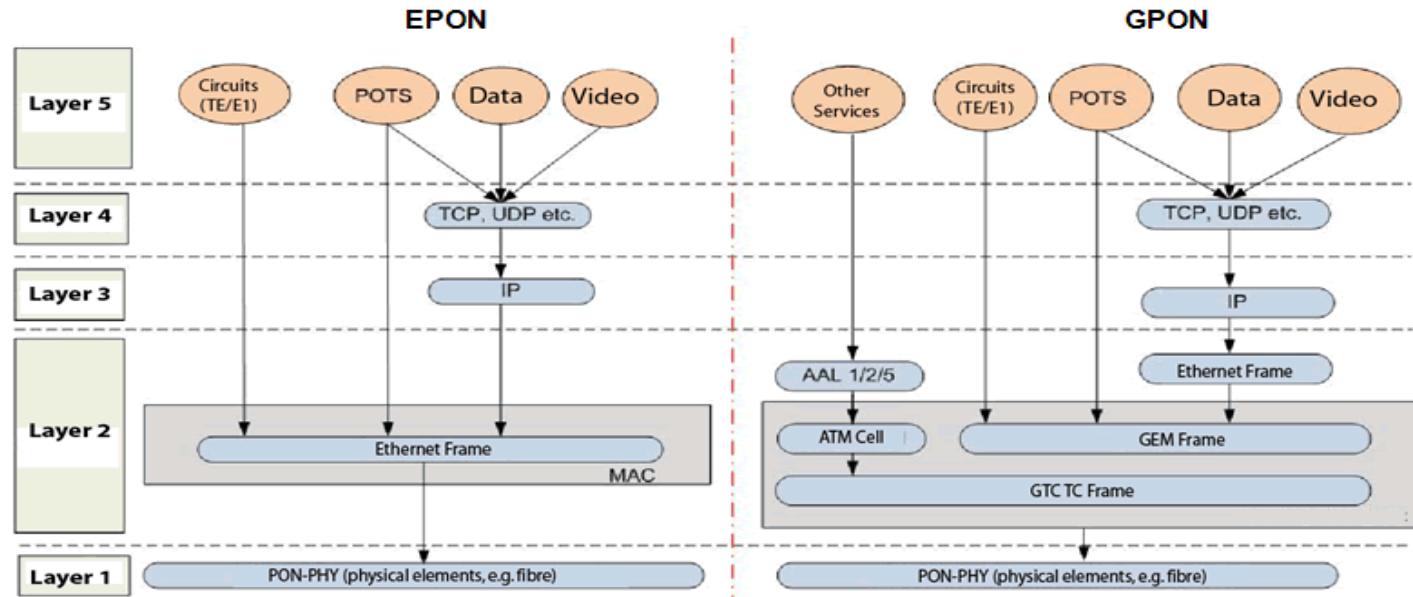
Active Optical Network (AON) and Passive Optical Network (PON)



Key: **A** - Data or voice for a single customer. **V** - Video for multiple customers.

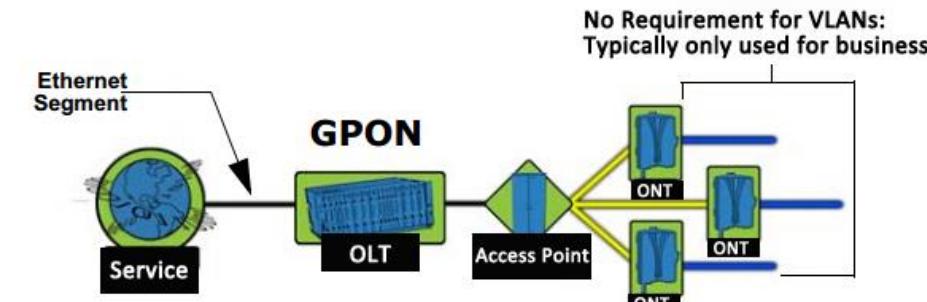
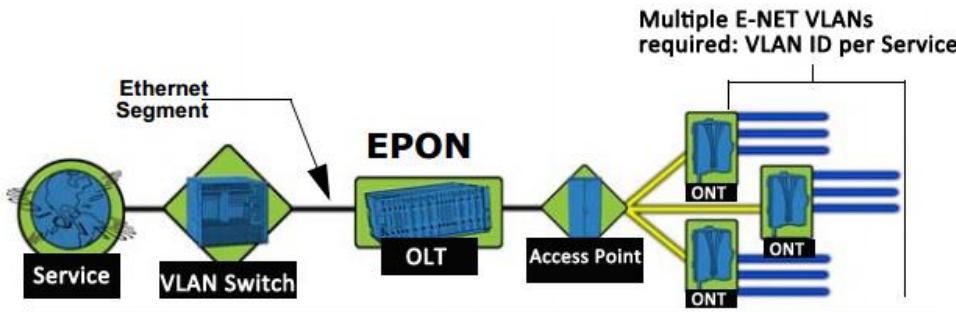
Fiber Optic Systems and Technologies

Ethernet PON (EPON) vs Gigabit PON (GPON)



Example of other services: IP over ATM, Ethernet over ATM, Switched megabit data service, LAN emulation, T1/E1 and x64 kps emulation, Voice over ATM

Fiber Optic Systems and Technologies



Category	EPON	GPON
standard	IEEE 802.3ah	ITU-T G.984
Upstream	1310nm	1310nm
Downstream	1550nm	1490&1550nm
Protocol	Ethernet	ATM, Ethernet, TDM, GEM
Bandwidth	Down ≤ 1.25Gbps UP ≤ 1.25Gbps	Down ≤ 2.4Gbps UP ≤ 2.4Gbps
Max Distance	10 or 20km	10 or 20km
Max Split Ratio	64 users	64 users

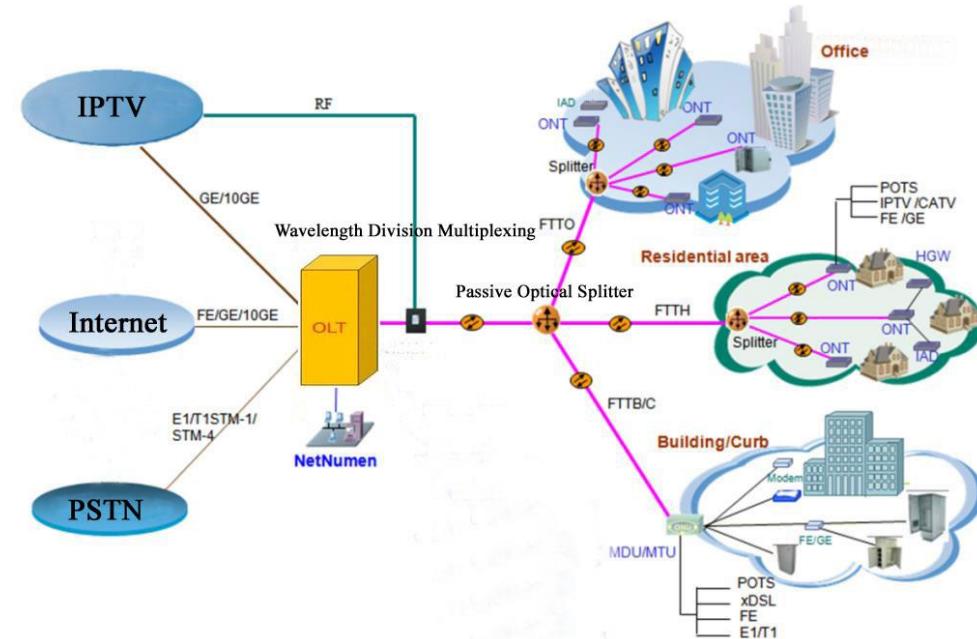
	IEEE 802.3ah (EPON)	ITU-T G.984 (GPON)
Downstream	1250 Mbps	2500 or 1250 Mbps
Upstream	1250 Mbps	1250 or 622 Mbps
Split ratio	1:32	1:32, 1:64, (1:128 planned)
Downstream Efficiency	~72% as a result of: 8B/10B encoding (20%) Overhead & Preamble (8%)	~92% as a result of: NRZ scrambling (no encoding) Overhead & Preamble (8%)
Revenue BW	900 Mbps	2300 Mbps
OAM&P	OAM is optional and minimally supports: failure indication, loop-back and link monitoring to the ONT. Provisioning and services are out of scope.	OMCI is mandatory. Full FCAPS on ONT and services.
Security	None specified. AES used by various vendors.	AES is part of the standard.
Network Protection	None specified.	Optional 50 mS switching time.
TDM transport	Circuit Emulation over Ethernet (ITU-T Y.1413 or MEF or IETF)	Native via GEM or Circuit Emulation over Ethernet (ITU-T Y.1413 or MEF or IETF)
Interoperability	None specified	FSAN and ITU-T

Fiber Optic Systems and Technologies

GPON aims at transmission speeds of at least 1.2 Gbps, with speed combinations of:

- 1.2 Gbps up, 2.4 Gbps down
- 2.4 Gbps up, 2.4 Gbps down

Services	Bandwidth
Data Download	10 Mbps
VoIP and video-conference	1 Mbps
Multimedia contents	2 Mbps
On-line Gaming	1 Mbps
SD Digital TV	3 Mbps
HD Digital TV	8 Mbps
Additional TV channels	16 Mbps



Fiber Optic Systems and Technologies

GPON Terminologies

- **Service** is defined as a network service required by the operators.
- **Optical Access Network** (OAN) is an access network towards the network side, it is also known as SNI (Service Network Interface).
- **Optical Distribution Network** is where all passive components from the PON Port of OLT to the PON Port of ONT come under in a PON Technology towards downstream side.
- **Physical Reach** is defined as the maximum physical distance between the ONU/ONT and the OLT. In GPON, two options are defined for the physical reach: 10 km and 20 km.
- **Logical Reach** is the maximum distance that can be covered for a particular transmission system, regardless of the optical budget. In GPON, the maximum logical reach is defined as 60 kms.

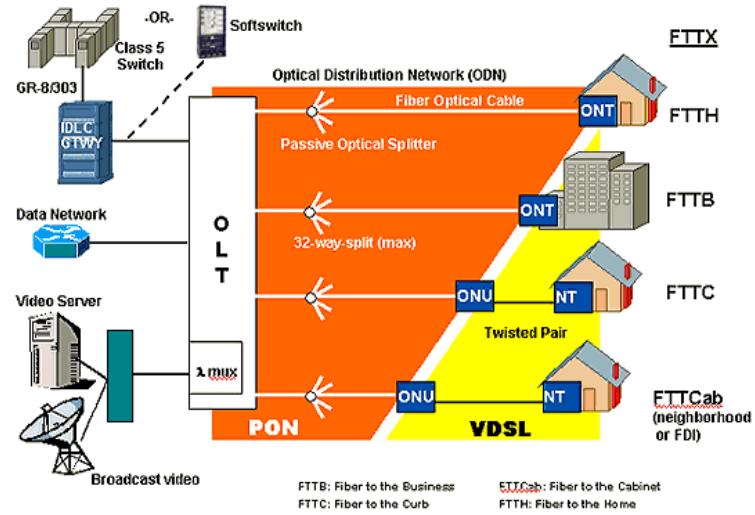
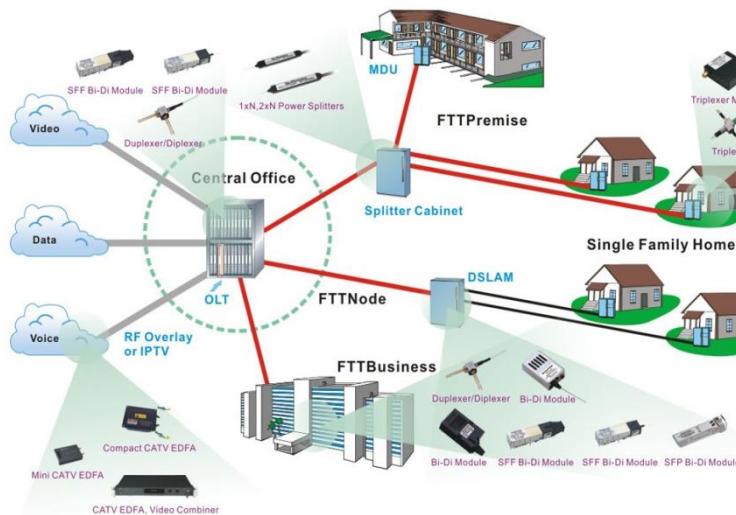
Fiber Optic Systems and Technologies

GPON Terminologies

- **Differential Fiber Distance** (DFT) is an OLT connected to several ONU/ONTs. The differential fiber distance is the difference in the distance between the nearest and the farthest ONU/ONT from the OLT. In GPON, the maximum differential fiber distance is 20 km.
- **Mean Signal Transfer Delay** is the average of the upstream and downstream delay values between reference points. This value is determined by measuring round-trip delay and then dividing by 2. GPON must accommodate services that require a maximum mean signal transfer delay of 1.5 ms.
- **Split Ratio** determines cost over optical power and bandwidth splitting, which creates the need for an increased power budget to support the physical reach. Split ratios of up to 1:64 are realistic for the physical layer, given current technology.

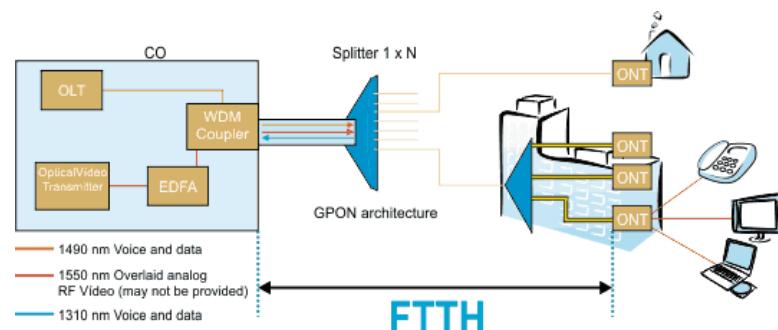
Fiber Optic Systems and Technologies

Fiber to the X (FTTx) or *fiber-in-the-loop* is a generic term for any broadband network architecture using optical fiber to provide all or part of the local loop used for last mile telecommunications.



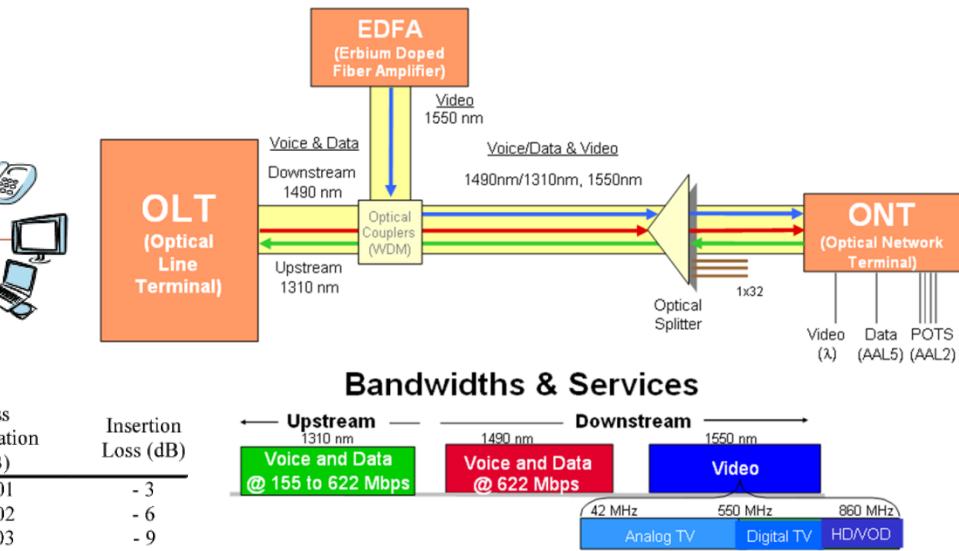
Fiber Optic Systems and Technologies

Fiber-to-the-Home (FTTH)



Optical Fiber Communication Bands

Band name	Description	Range [nm]	Splitting Ratio	Power per User (%)	Loss Calculation (dB)	Insertion Loss (dB)
O-band	Original	1260-1360	1:2	50.00 %	- 3.01	- 3
E-band	Extended	1360-1460	1:4	25.00 %	- 6.02	- 6
S-band	Short wavelength	1460-1530	1:8	12.50 %	- 9.03	- 9
C-band	Conventional	1530-1565	1:16	6.25 %	- 12.04	- 12
L-band	Long wavelength	1565-1625	1:32	3.13 %	- 15.04	- 15
U-band	Ultra-long wavelength	1625-1675	1:64	1.56 %	- 18.07	- 18
			1:128	0.78 %	- 21.08	- 21



Fiber Optic Systems and Technologies

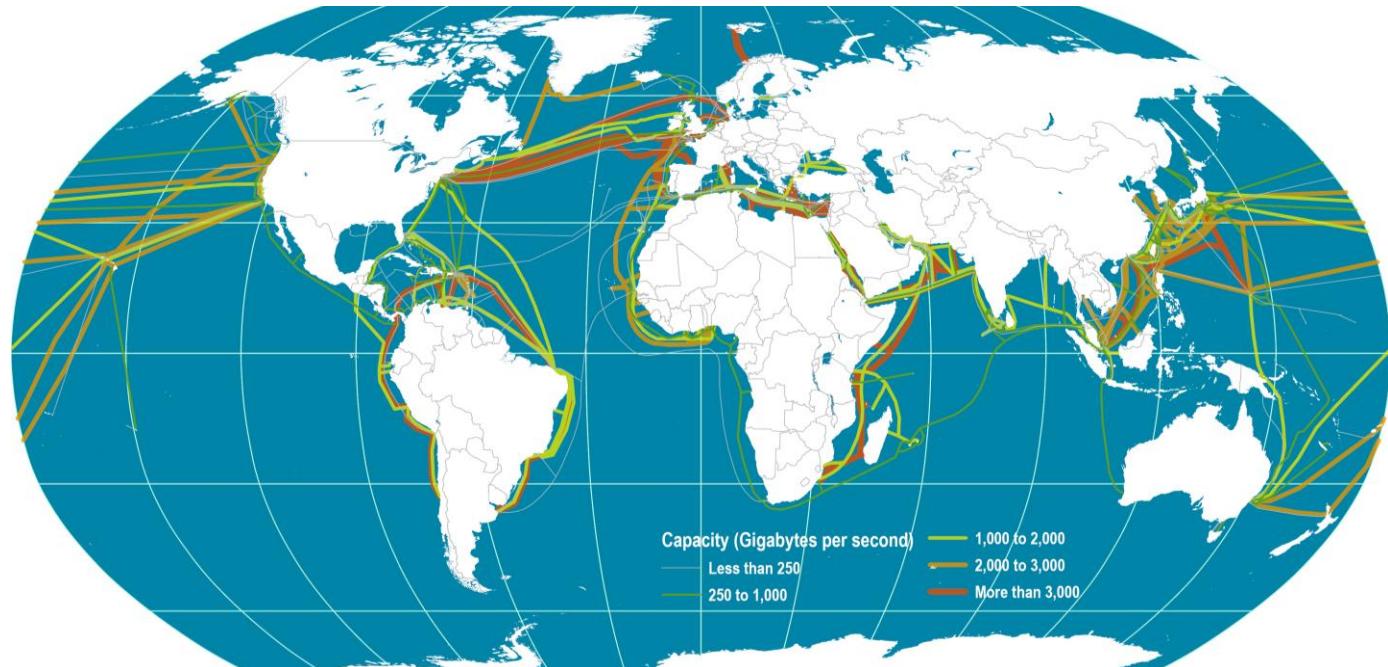
DSL vs FTTH PON Data Rates

Transport	ADSL	ADSL2	ADSL2+	VDSL	VDSL2	FTTH PON
Max bandwidth	D:8M	12M	24M	55M	100M	100+
	U:1M	3.5M	1M	19M	100M	100+
Distance	3-5KM			<=1.3KM		<=100KM

- **ISDN:** $2B + D = 2 \times 64 + 16 = 144$ Kbps
- **HDSDN:** American standard 0.51mm, 2Mbps at max 5km.
- **ADSL:** 3-5 km 8 Mbps
- **ADSL2:** 3-5 km 12 Mbps
- **ADSL2+:** 3-5 km 24 Mbps
- **VDSL:** ≤ 1.3 km, 55 Mbps; VDSL2 upstream/downstream 100 Mbps

Fiber Optic Systems and Technologies

Global Submarine Cable Network



**Whatever you do, work heartily,
as for the Lord and not for men**

Colossians 3:23



Thank You!

Engr. Marvin De Pedro

marvin.depedro@gmail.com

09673873810