NETWORK ACCESS

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Postgraduate Program, Informatics Engineering (S2)

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References :

- Computer Networks - A Tanenbaum - 5th edition (2011)
- Data Communications and Networking - Behrouz A.Forouzan - 4th edition (2007)
- Cisco System Inc - 2011 - Cisco Configuration Profesional User Guide.

Chapter 3: Objectives

After completing this chapter, students will be able to:

- Identify device connectivity options.
- Describe the purpose and functions of the physical layer in the network.
- Describe basic principles of the physical layer standards.
- Select the appropriate media for a given requirement and connect devices.
- Describe the purpose and function of the data link layer in preparing communication for transmission on specific media.
- Describe the Layer 2 frame structure and identify generic fields.
- Describe the characteristics and functions of the data link frame.

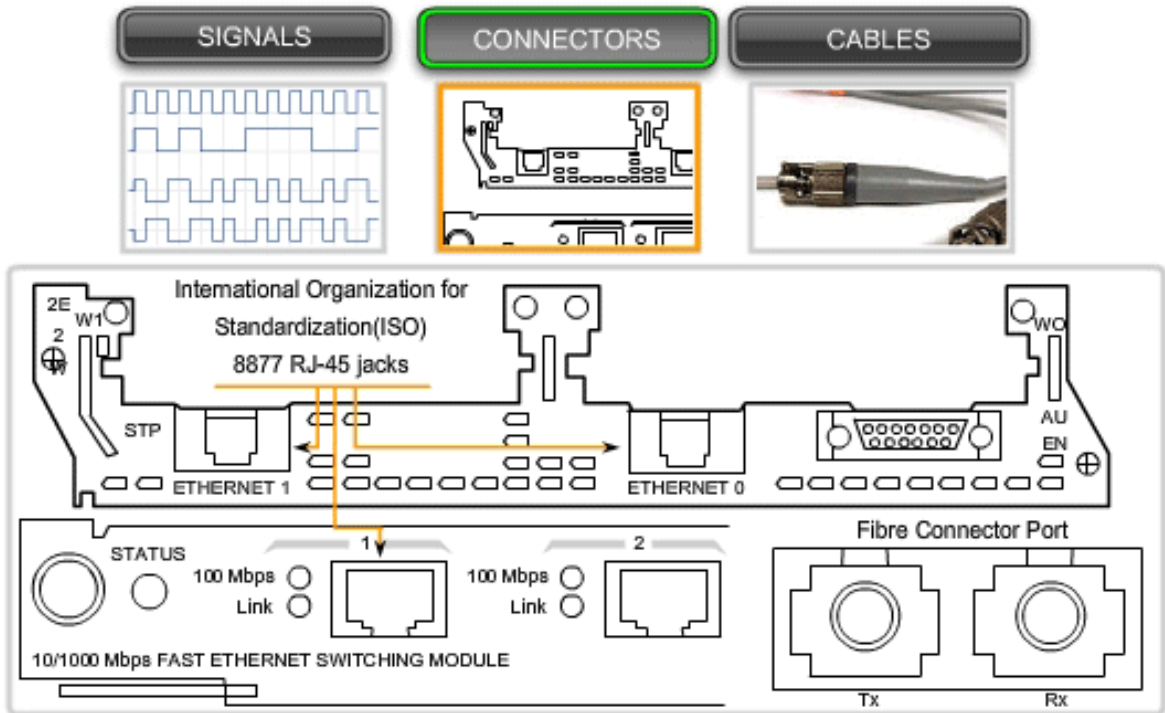
Chapter 3:

- 3.1 Physical Layer Protocols
- 3.2 Network Media
- 3.3 Data Link Layer Protocols
- 3.4 Media Access Control

3.1 Physical Layer Protocols

Physical Layer

Standards for the Physical layer specify signal, connector, and cabling requirements.



Outline of Physical Layer

- It defines the electrical, timing and their interfaces by which bits are sent as signals over the channel.
- Foundation on which the network is built.
- The properties of different kinds of physical channel determine the performance throughput, latency, and error rate.

Outline of Physical Layer

- Digital Modulation: How analog signals are converted into digital bits and back again.
- Multiplexing Schemes: Exploring how multiple conversations can be put on the same transmission medium at the same time without interfering with one another.

Theoretical Basis for Data Communication

- Fourier analysis.
- Bandwidth-limited signals.
- Maximum data rate of a channel

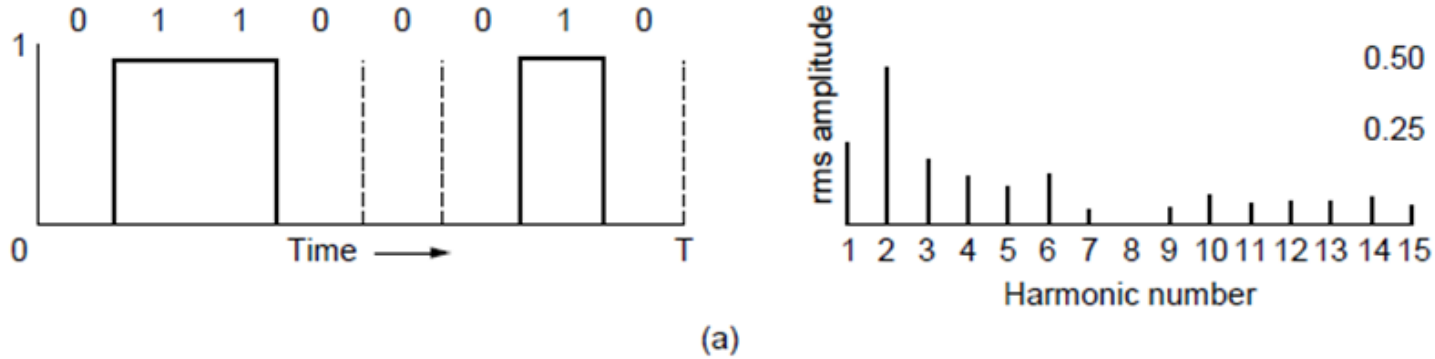
Fourier Analysis

- We model the behavior of variation of voltage or current with mathematical functions.
- Fourier series is used to expand any periodic function with period T

$$g(t) = 1/2c + \sum_{n=1}^{\infty} a_n \sin(2\pi nft) + \sum_{n=1}^{\infty} b_n \cos(2\pi nft)$$

- $f = 1/T$ fundamental frequency.
- an, bn are the sine and cosine amplitudes of the nth harmonic.
- c is a constant

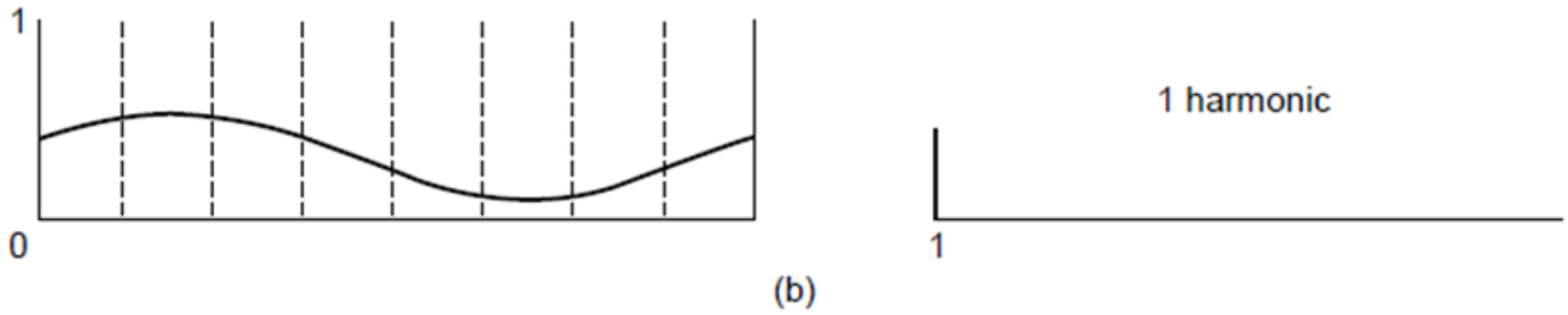
Bandwidth-Limited Signals (1)



(a)

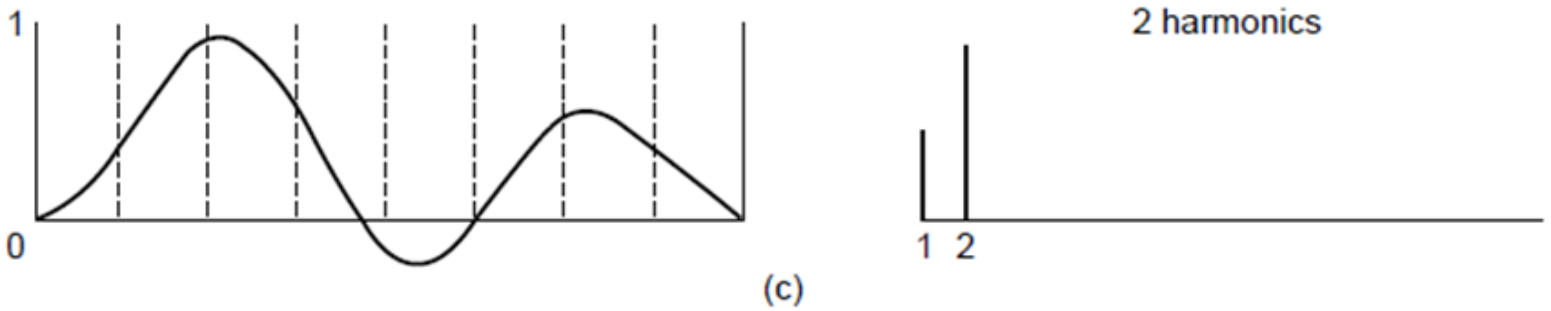
A binary signal and its root-mean-square Fourier amplitudes.

Bandwidth-Limited Signals (2)



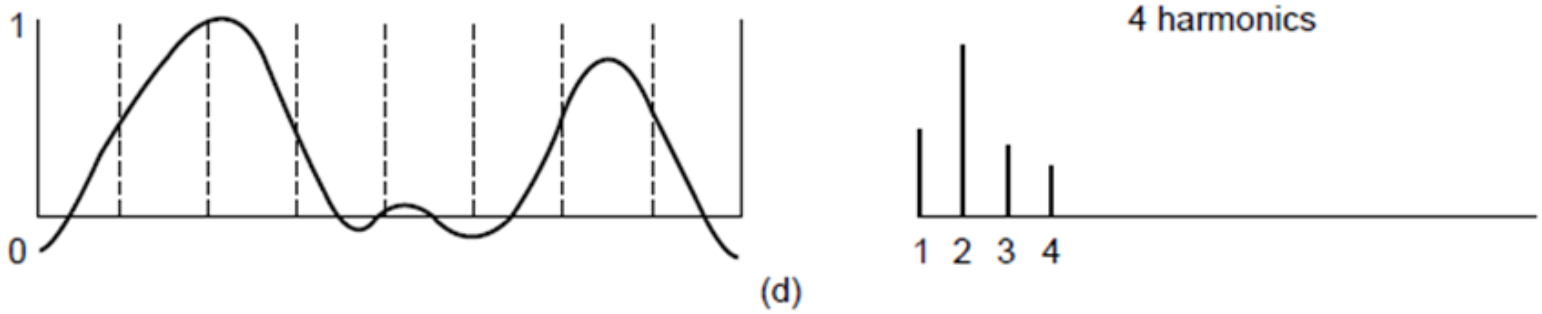
(b)-(e) Successive approximations to the original signal

Bandwidth-Limited Signals (3)



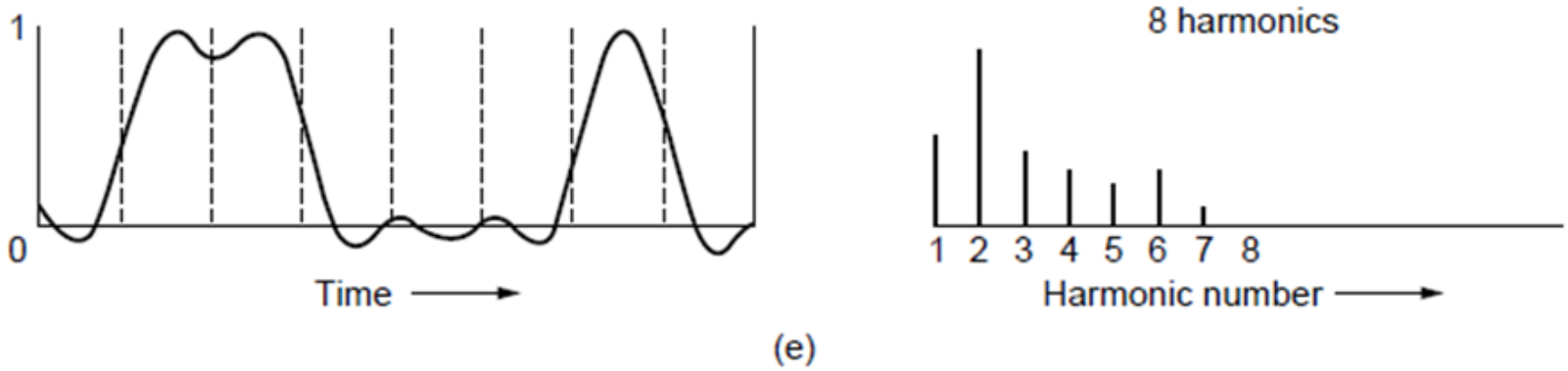
(b)-(e) Successive approximations to the original signal.

Bandwidth-Limited Signals (4)



(b)-(e) Successive approximations to the original signal

Bandwidth-Limited Signals (5)



(b)-(e) Successive approximations to the original signal

The Maximum Data Rate of a Channel

- Nyquists theorem

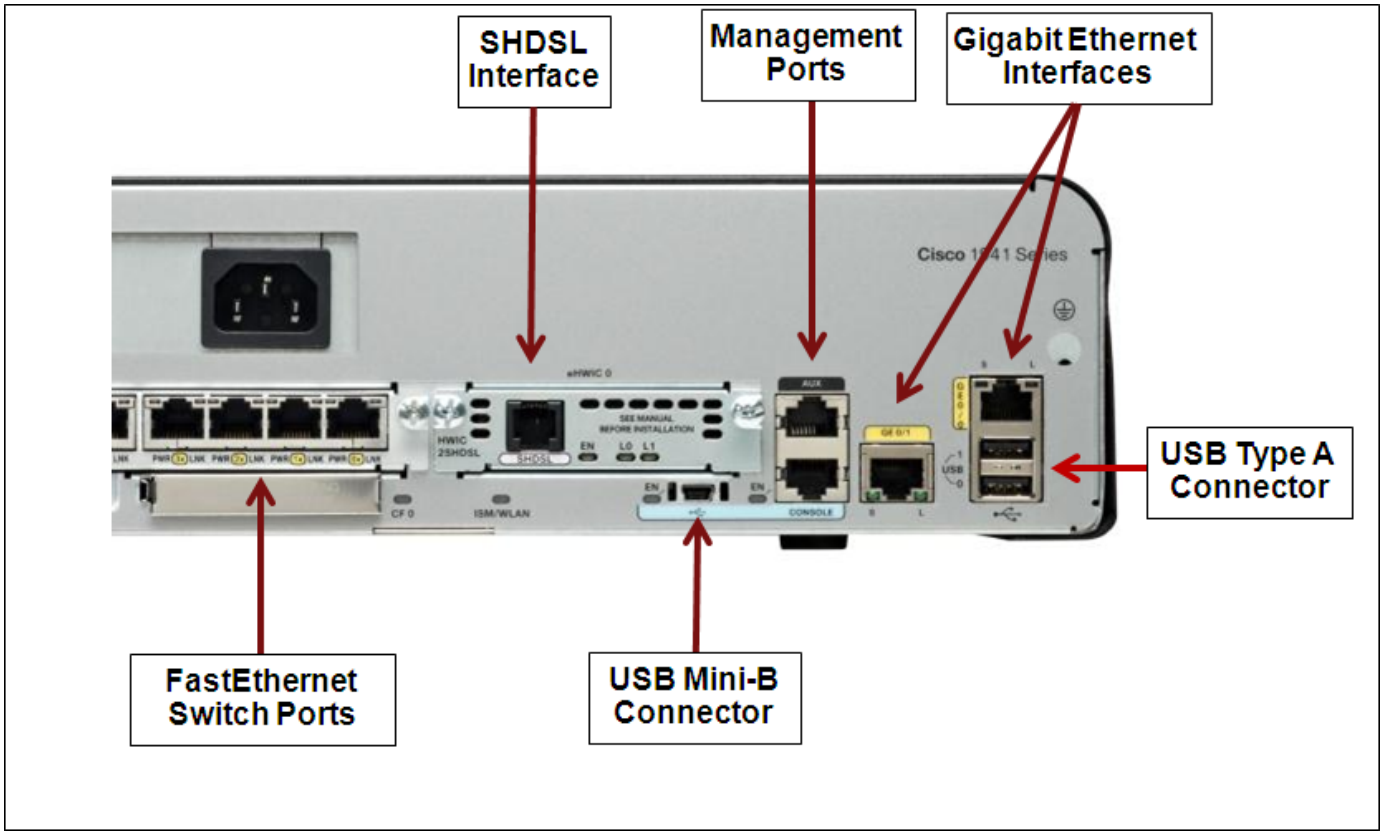
$$\textit{maximum data rate} = 2B \log_2 \textit{bits/sec}$$

- Shannons formula for capacity of a noisy channel

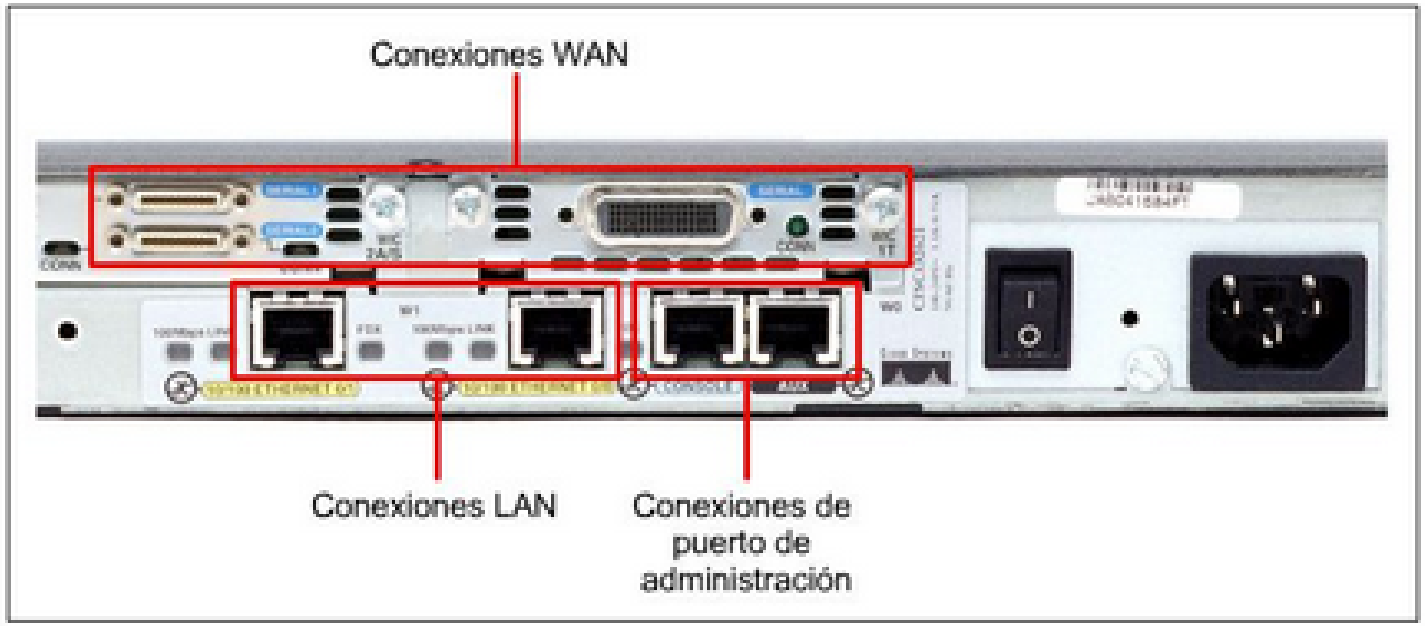
$$\textit{maximum number of bits/sec} = B \log_2(1 + S/N)$$

- S/N is called Signal to Noise Ratio (SNR)

Types of Physical Media



Types of Physical Media



Physical Layer Standards

Standard Organization	Networking Standards
ISO	• ISO 8877: Officially adopted the RJ connectors (e.g., RJ-11, RJ-45) • ISO 11801: Network cabling standard similar to EIA/TIA 568.
EIA/TIA	• TIA-568-C: Telecommunications cabling standards, used by nearly all voice, video and data networks. • TIA-569-B: Commercial Building Standards for Telecommunications Pathways and Spaces • TIA-598-C: Fiber optic color coding • TIA-942: Telecommunications Infrastructure Standard for Data Centers
ANSI	• 568-C: RJ-45 pinouts. Co-developed with EIA/TIA
ITU-T	• G.992: ADSL
IEEE	• 802.3: Ethernet • 802.11: Wireless LAN (WLAN) & Mesh (Wi-Fi certification) • 802.15: Bluetooth

3.2 Network Media

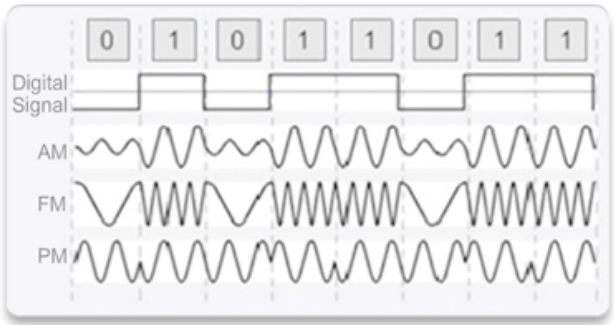
Network Media

Electrical Signals -
Copper cable

Copper Media / Cable

Light Pulse -
Fiber-optic cable

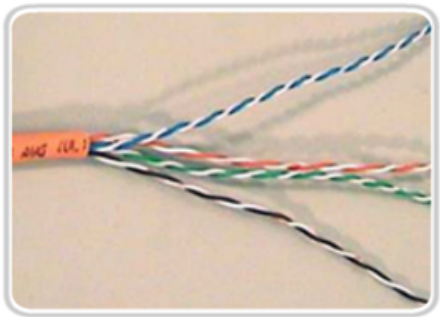
Fiber Optic Media



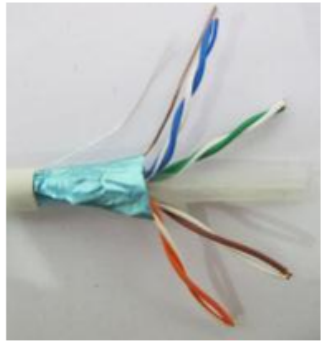
Microwave Signals -
Wireless

Wireless Media

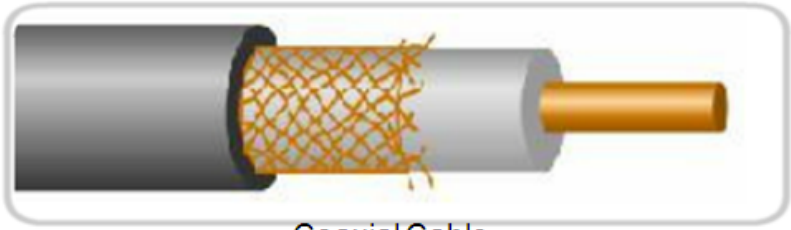
Copper Media



Unshielded Twisted Pair (UTP) Cable

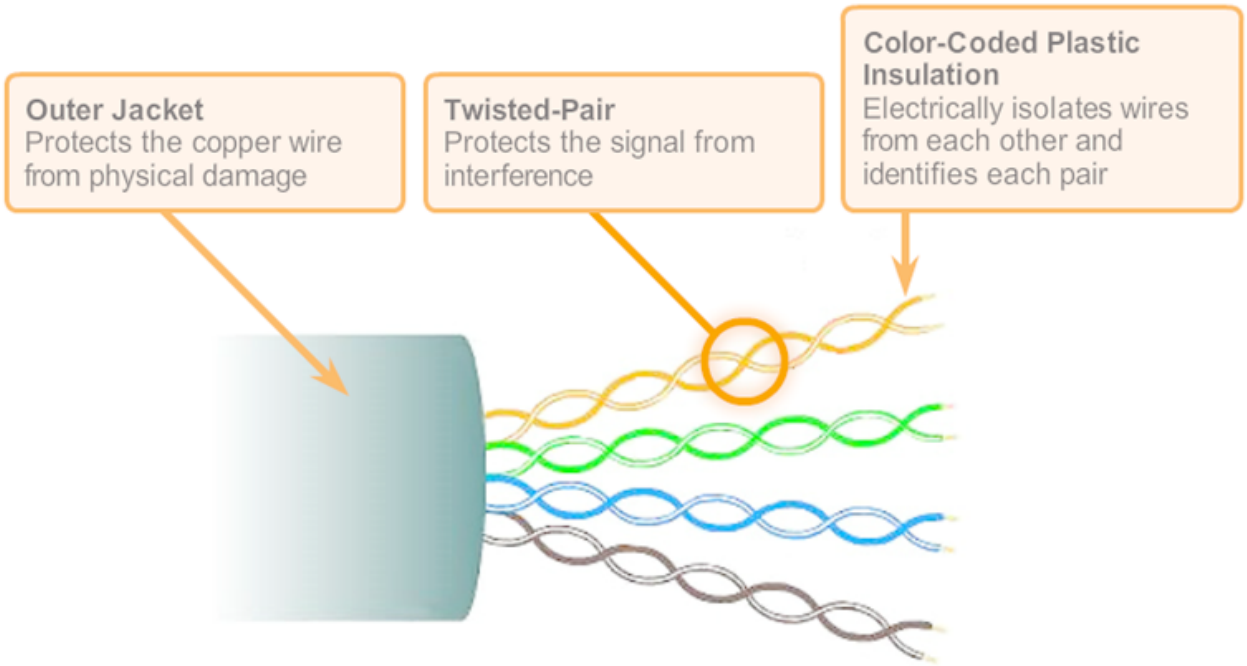


Shielded Twisted Pair (STP) Cable



Coaxial Cable

UTP Cable

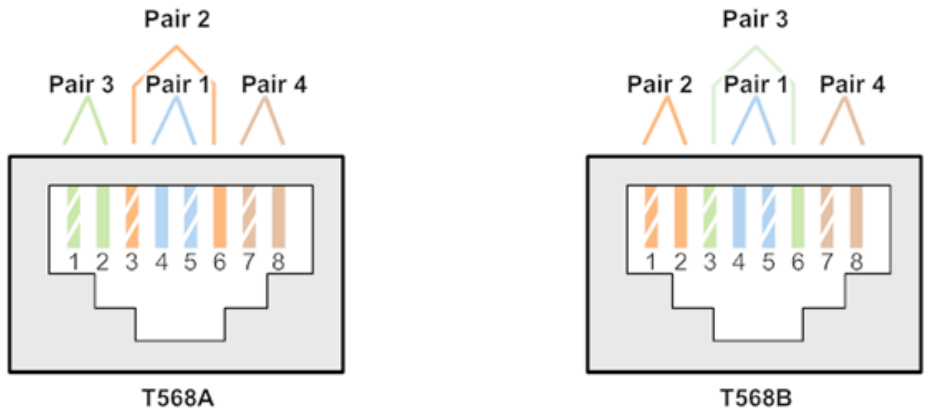

Outer Jacket
Protects the copper wire from physical damage
Twisted-Pair
Protects the signal from interference
Color-Coded Plastic Insulation
Electrically isolates wires from each other and identifies each pair

Properties of UTP Cabling

UTP cable does not use shielding to counter the effects of EMI and RFI. Instead, cable designers have discovered that they can limit the negative effect of crosstalk by:

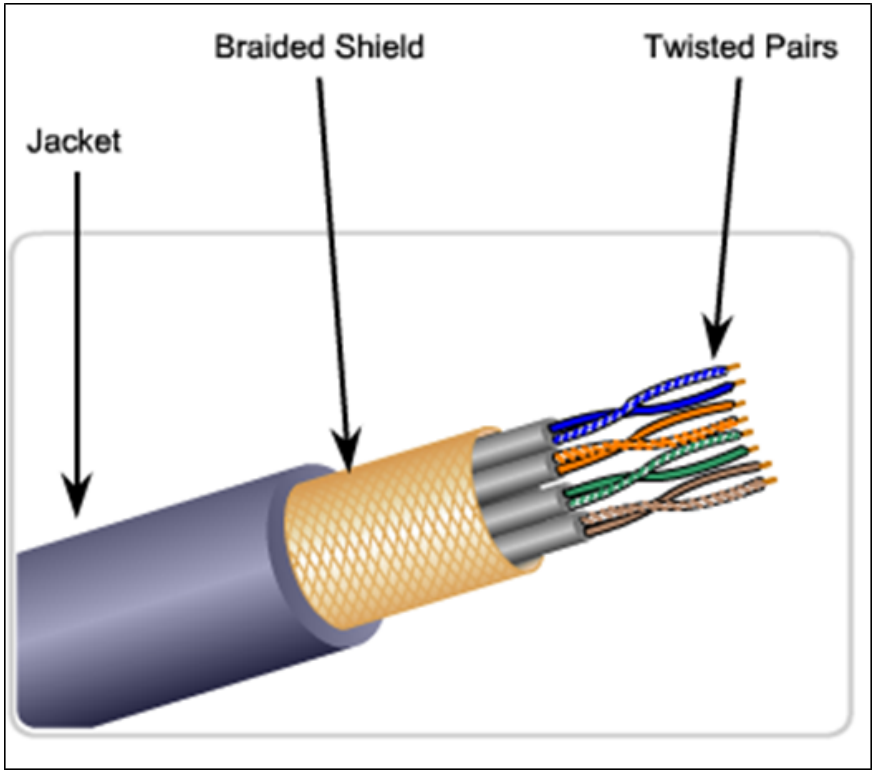
- Cancellation
- Varying the number of twists per wire pair

Types of UTP Cable

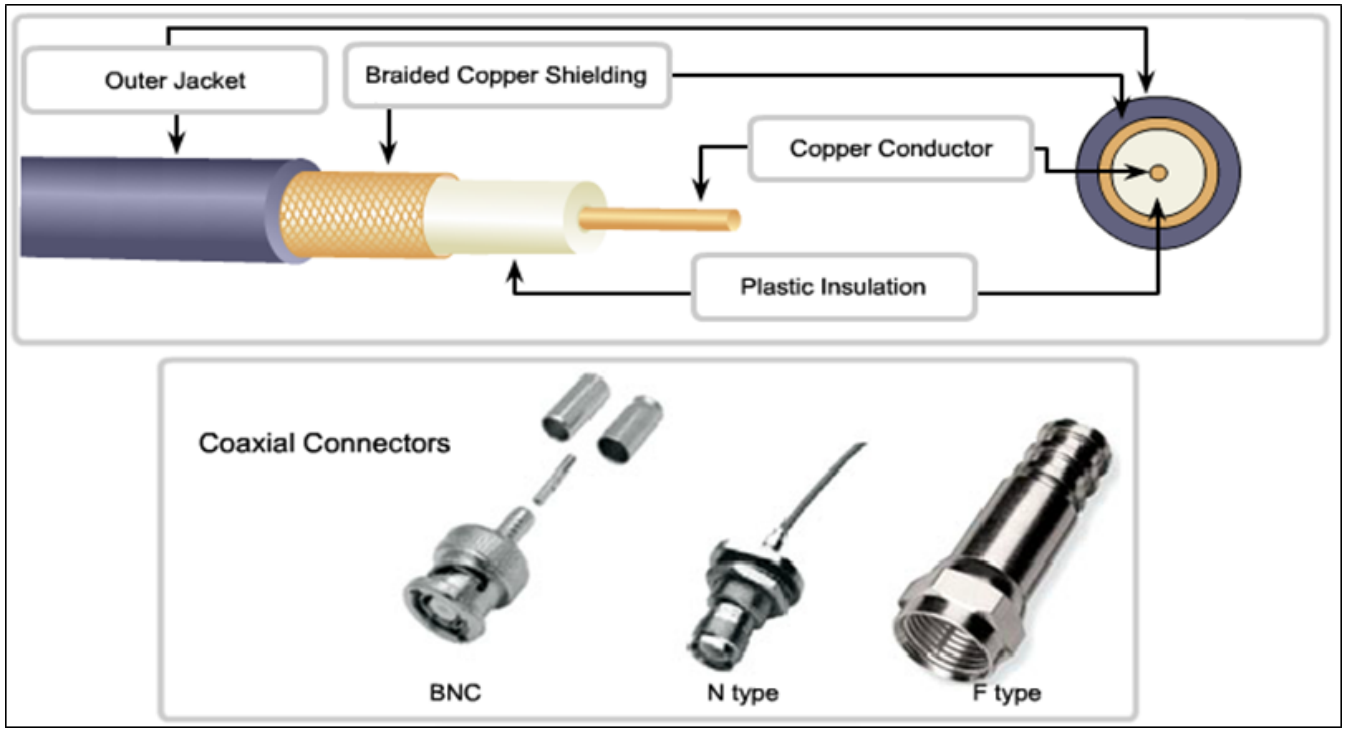


Cable Type	Standard	Application
Ethernet Straight-through	Both ends T568A or both ends T568B	Connects a network host to a network device such as a switch or hub.
Ethernet Crossover	One end T568A, other end T568B	• Connects two network hosts • Connects two network intermediary devices (switch to switch, or router to router)
Rollover	Cisco proprietary	Connects a workstation serial port to a router console port, using an adapter.

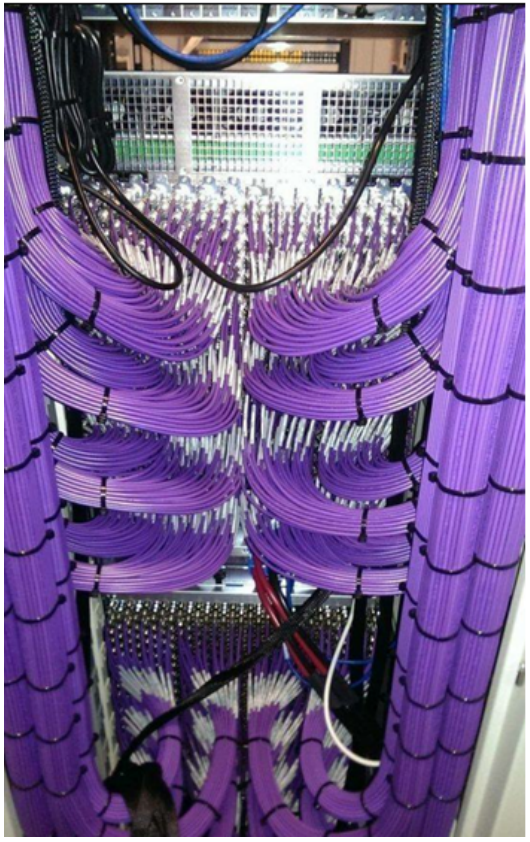
STP Cable

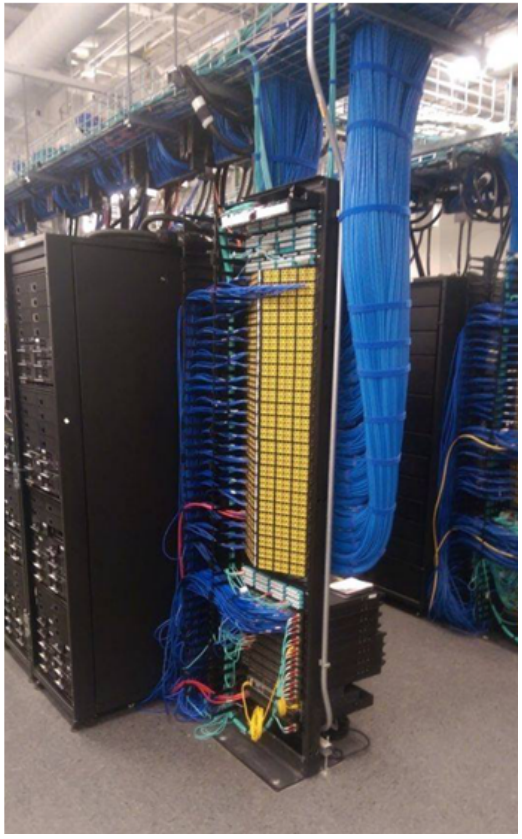


Coaxial Cable

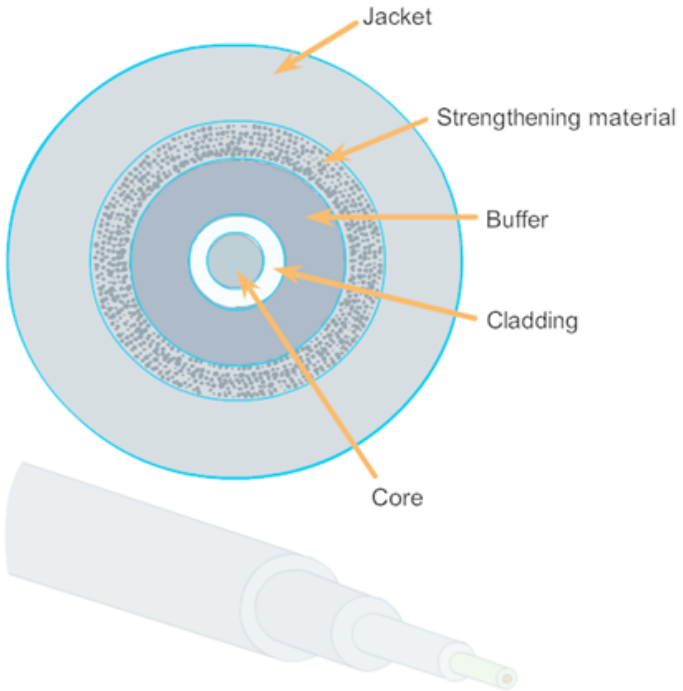


Cable Manajement





Fiber Media Cable Design

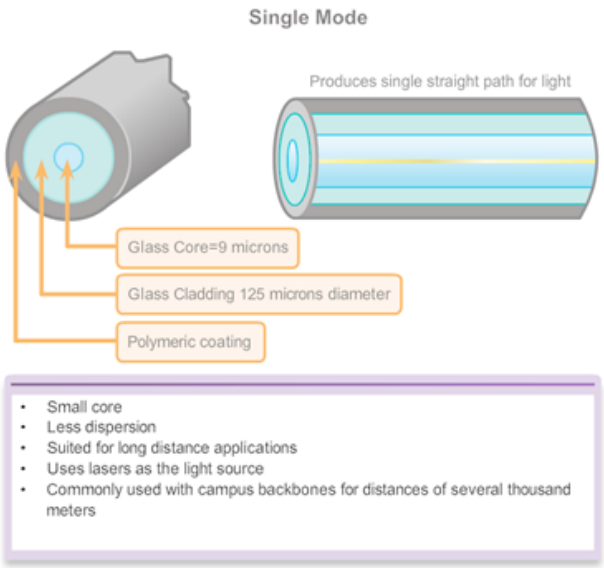


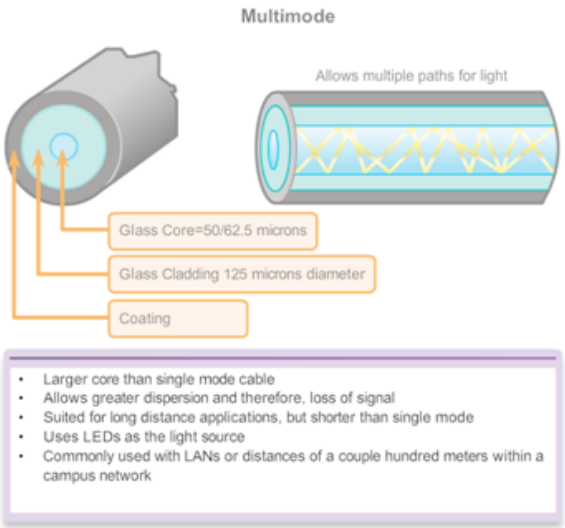
Properties of Fiber Optic Cabling

Fiber-optic cabling is now being used in four types of industry:

- Enterprise Networks
- Fiber-to-the-home (FTTH) and Access Networks
- Long-Haul Networks
- Submarine Networks

Types of Fiber Media





Fiber versus Copper

Implementation Issues	Copper Media	Fibre Optic
Bandwidth Supported	10 Mbps – 10 Gbps	10 Mbps – 100 Gbps
Distance	Relatively short (1 – 100 meters)	Relatively High (1 – 100,000 meters)
Immunity To EMI And RFI	Low	High (Completely immune)
Immunity To Electrical Hazards	Low	High (Completely immune)
Media And Connector Costs	Lowest	Highest
Installation Skills Required	Lowest	Highest
Safety Precautions	Lowest	Highest

Types of Wireless Media

Wi Fi	• IEEE 802.11 standards
	• Commonly referred to as Wi-Fi.
	• Uses CSMA/CA
	• Variations include:
	  • 802.11a: 54 Mbps, 5 GHz
	  • 802.11b: 11 Mbps, 2.4 GHz
	  • 802.11g: 54 Mbps, 2.4 GHz
	  • 802.11n: 600 Mbps, 2.4 and 5 GHz
	  • 802.11ac: 1 Gbps, 5 GHz
	  • 802.11ad: 7 Gbps, 2.4 GHz, 5 GHz, and 60 GHz

Bluetooth®	• IEEE 802.15 standard • Supports speeds up to 3 Mb/s • Provides device pairing over distances from 1 to 100 meters.
WiMAX	• IEEE 802.16 standard • Provides speeds up to 1 Gbps • Uses a point-to-multipoint topology to provide wireless broadband access.

Properties of Wireless Media

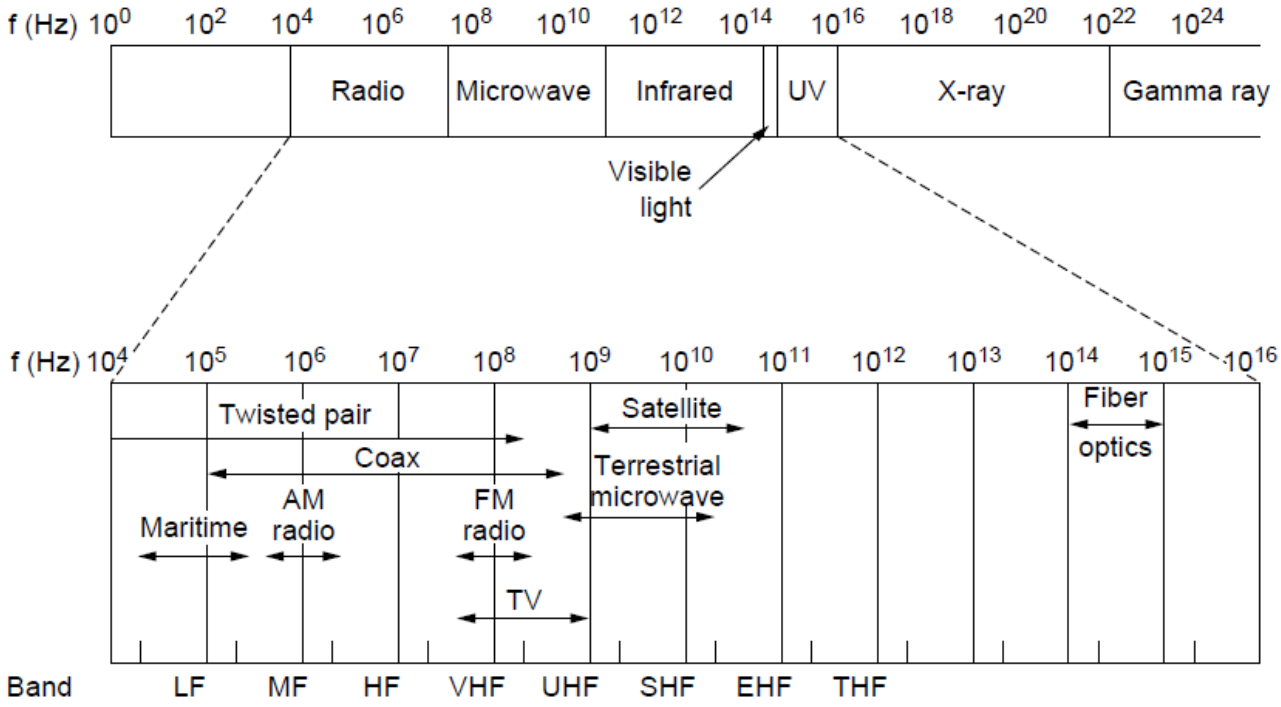
Wireless does have some areas of concern including:

- Coverage area
- Interference
- Security

Wireless Transmission

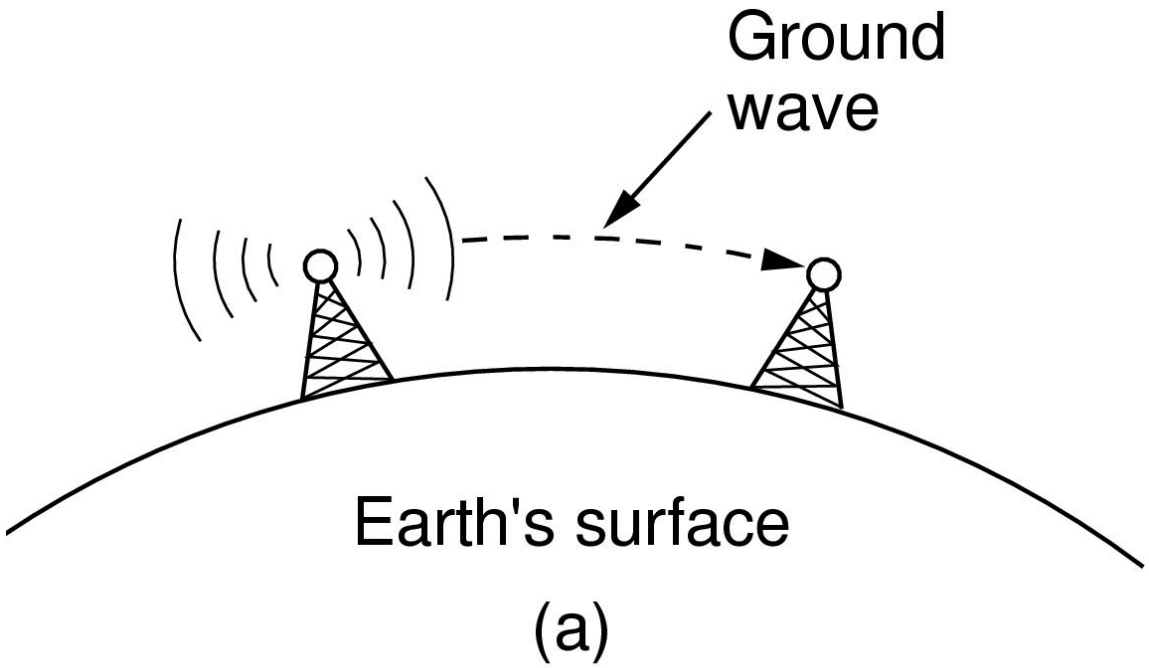
- The Electromagnetic Spectrum
- Radio Transmission
- Microwave Transmission
- Infrared Transmission
- Light Transmission

The Electromagnetic Spectrum



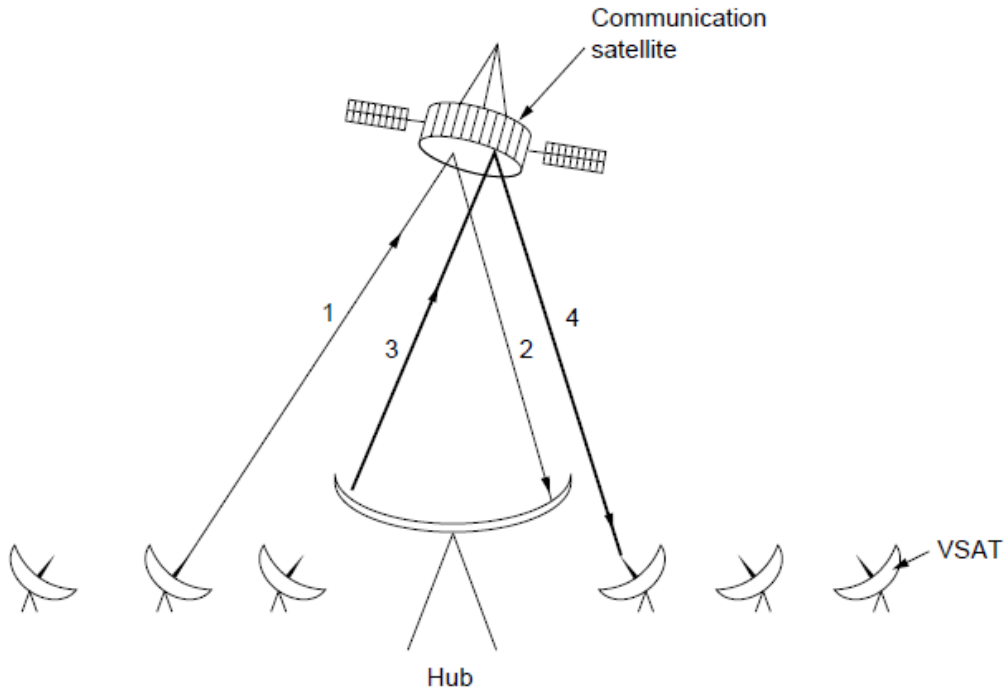
The electromagnetic spectrum and its uses for communication

Radio Transmission



In the VLF, LF, and MF bands, radio waves follow the curvature of the earth

Geostationary Satellites



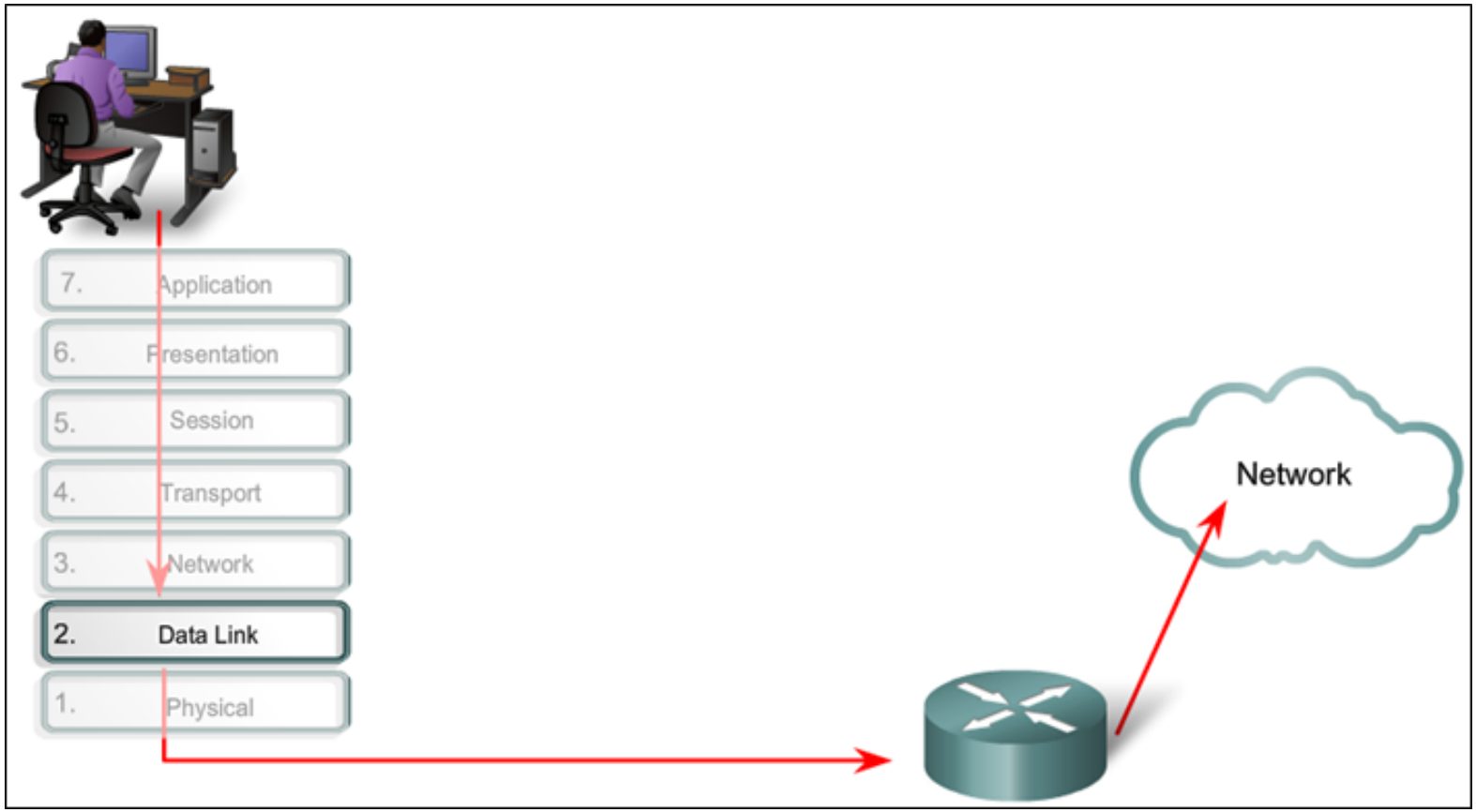
VSATs using a hub

Physical Layer Fundamental Principles

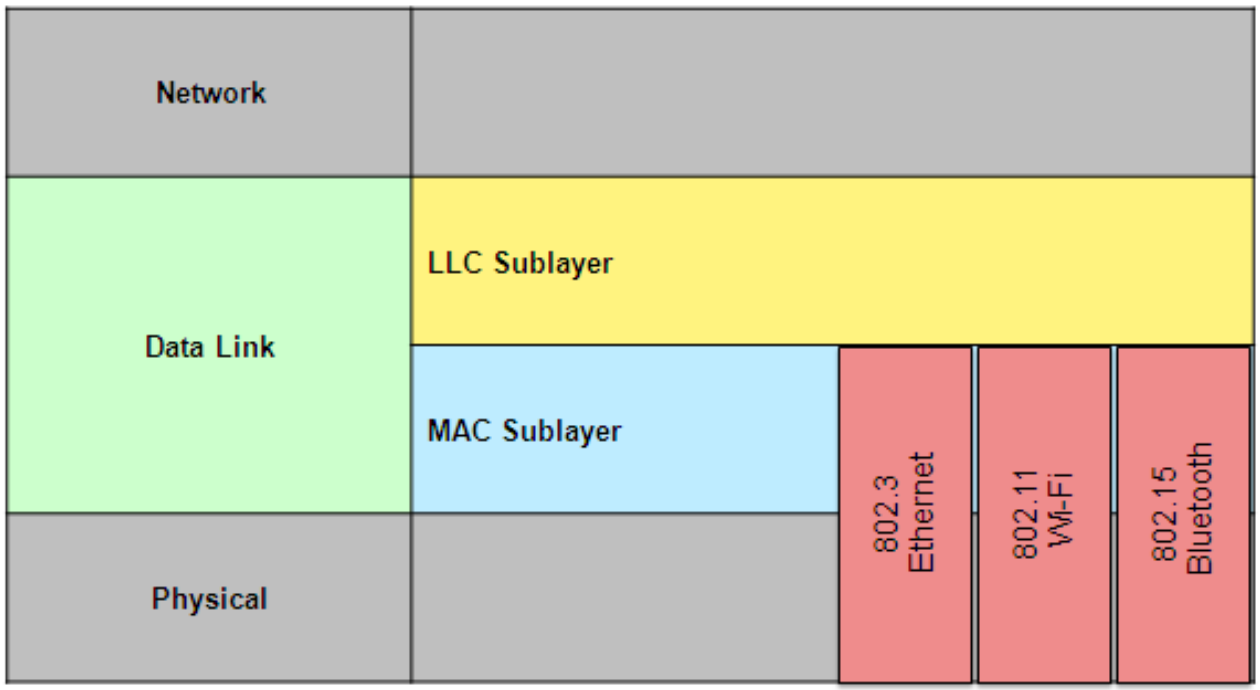
Media	Physical Components	Frame Encoding Technique	Signalling Method
Copper Cable	• UTP • Coaxial • Connectors • NICs • Ports • Interfaces	• Manchester Encoding • Non-Return to Zero (NRZ) techniques • 4B/5B codes are used with Multi-Level Transition Level 3 (MLT-3) signaling • 8B/10B • PAM5	• Changes in the electromagnetic field • Intensity of the electromagnetic field • Phase of the electromagnetic wave
Fiber Optic Cable	• Single-mode Fiber • Multimode Fiber • Connectors • NICs • Interfaces • Lasers and LEDs • Photoreceptors	• Pulses of light • Wavelength multiplexing using different colors	• A pulse equals 1. • No pulse is 0.
Wireless Media	• Access Points • NICs • Radio • Antennae	• DSSS (direct-sequence spread-spectrum) • OFDM (orthogonal frequency division multiplexing)	• Radio waves

3.3 Data Link Layer Protocols

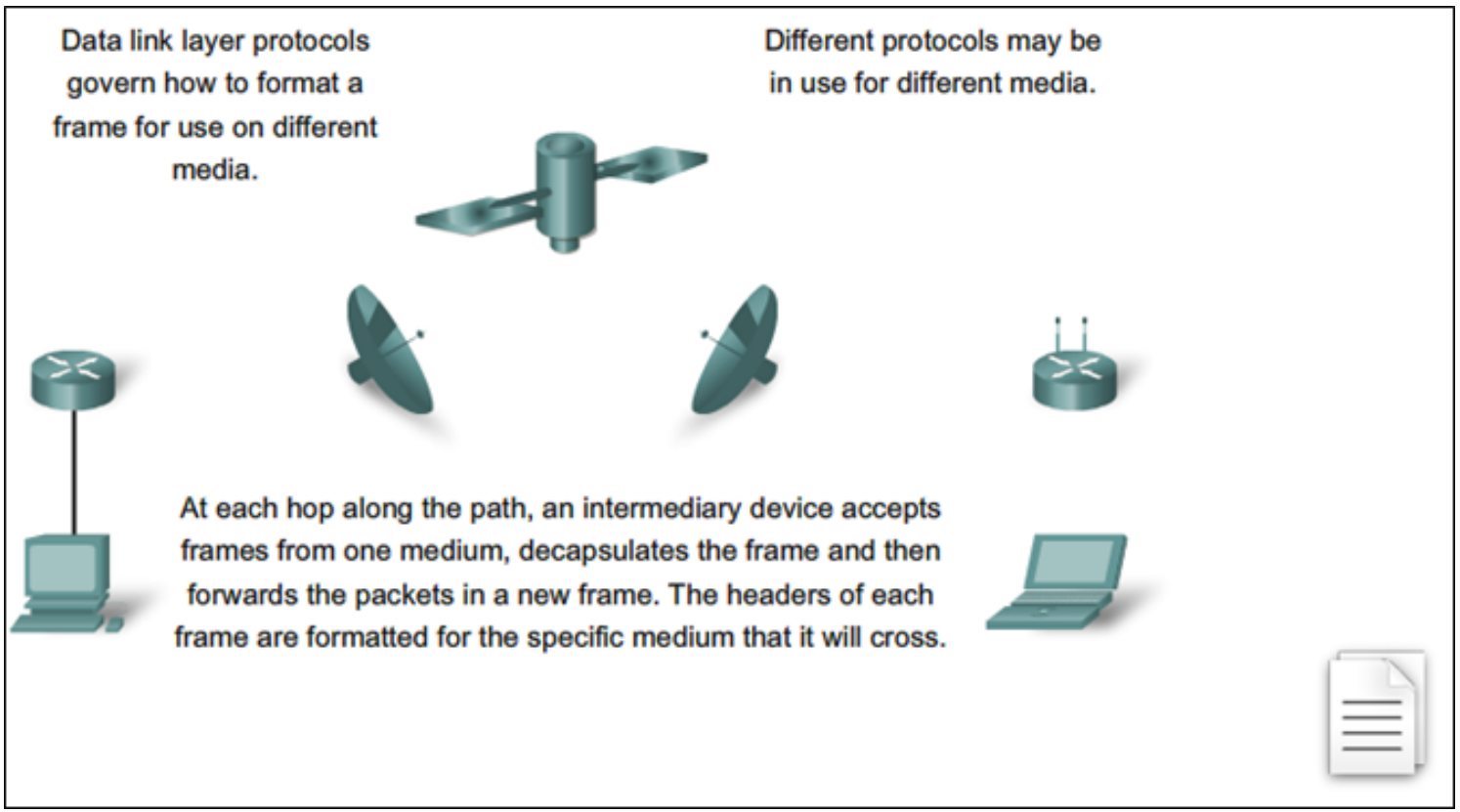
The Data Link Layer



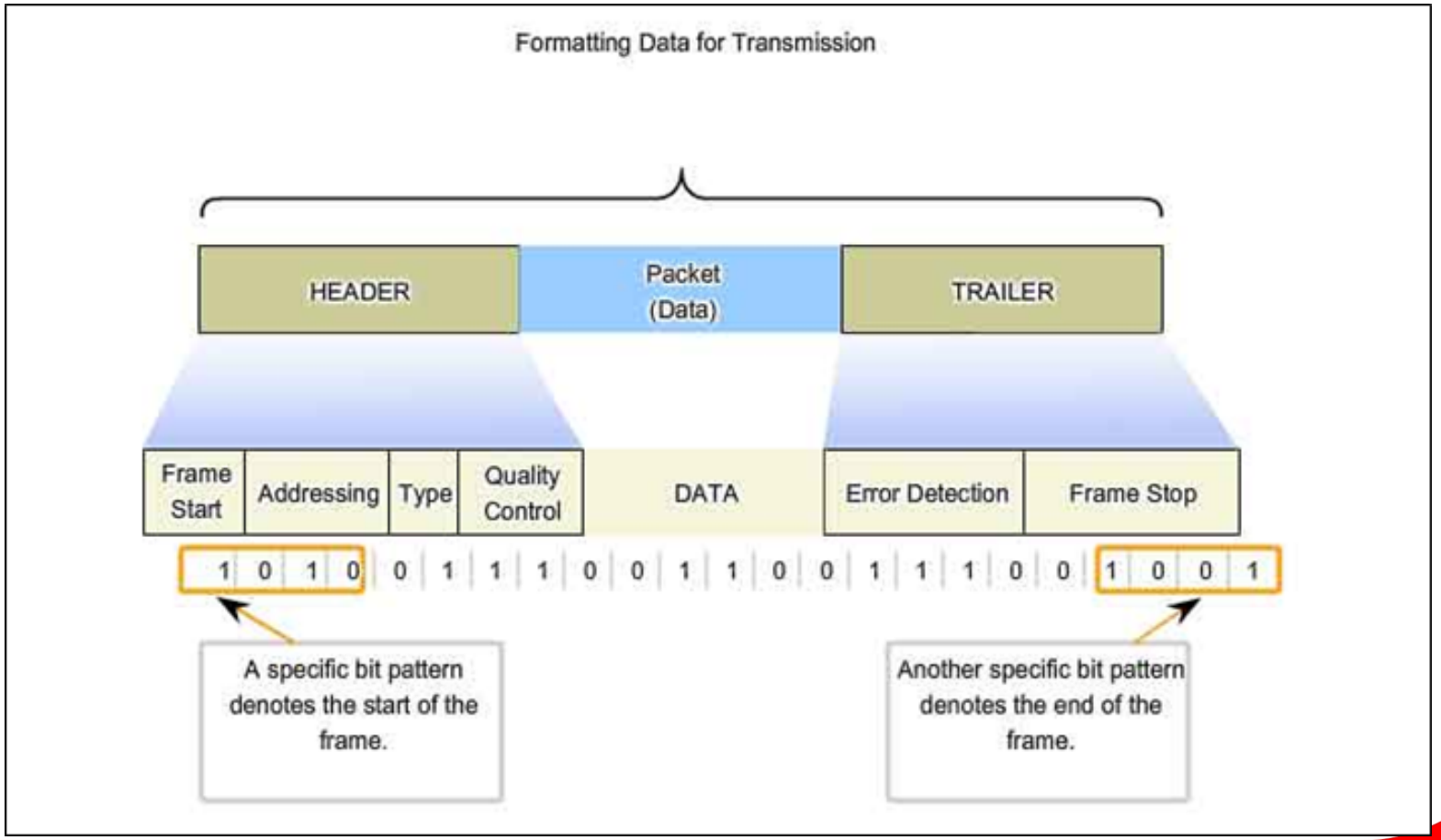
Data Link Sublayers



Media Access Control



Formatting Data for Transmission



Data Link Layer Standards

Standard organization	Networking Standards
IEEE	• 802.2: Logical Link Control (LLC) • 802.3: Ethernet • 802.4: Token bus • 802.5: Token passing • 802.11: Wireless LAN (WLAN) & Mesh (Wi-Fi certification) • 802.15: Bluetooth • 802.16: WiMax
ITU-T	• G.992: ADSL • G.8100 - G.8199: MPLS over Transport aspects • Q.921: ISDN • Q.922: Frame Relay
ISO	• HDLC (High Level Data Link Control) • ISO 9314: FDDI Media Access Control (MAC)
ANSI	• X3T9.5 and X3T12: Fiber Distributed Data Interface (FDDI)

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Road to 2025

IT Based International Standard