FACULTY OF TECHNOLOGY
UNIVERSITY OF COLOMBO
SRI LANKA

Computer Networks

Lecture 2: **OIS Model and Media Types**

Department of Information and Communication Technology

Outline of the syllabus

- Week 1 – Introduction to Network
- Week 2 – OSI Model and Media Types
- Week 3 – Devices and their functions
- Week 4 – ISO OSI seven Layer Architecture
- Week 5 – Application Layer
- Week 6 – Presentation layer
- Week 7 – Session layer

Outline of the syllabus

- Week 8 – Transport Layer
- Week 9 – Network Layer
- Week 10 – Data Link layer
- Week 11 – Physical layer.
- Week 12 - Routing techniques
- Week 13– how to setup local area networrk
- Week 14 – Revision

Learning Objectives

After completing this module, you will be able to:

- Understand what is a Computer Network, classification of Networks, and data communication
- Media types and devices (cables, routers, switches, hubs)
- Network Topology and ISO OSI reference models
- TCP/IP Model and comparison with ISO OSI model
- Understand the layers in detail
- Formation of IP address and routing techniques.
- Set up a local area network having all the features.

Lecture -2 Outline

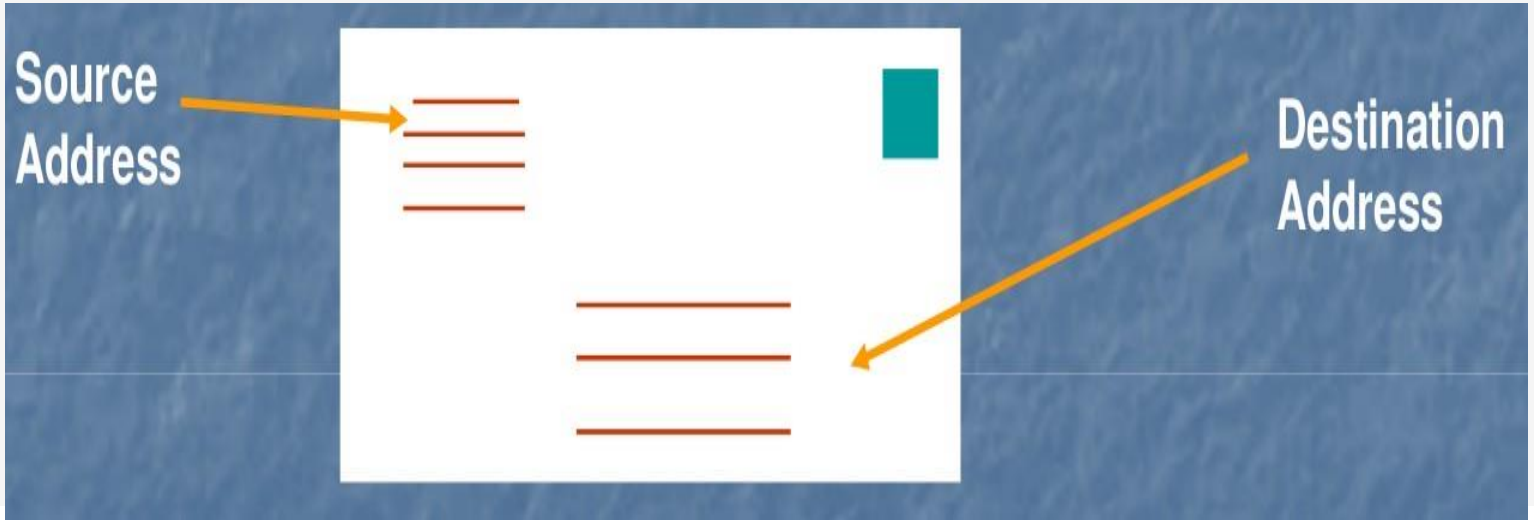
- What is computer Network?
- classification of Network
- Public Networks
- Data Communication
- Analog and Digital Signals
- Data Transmission

Lecture -1 Outline

- How is data transmitted?
- Layered Architecture
- OSI Reference Model
- OSI model vs. TCP/IP model
- Physical Layer

How data is transmitted?

- Information is placed in packets
- Packets are like envelopes that carry information to its destination
- What a packet looks like is defined by the network protocol



Layered Architecture

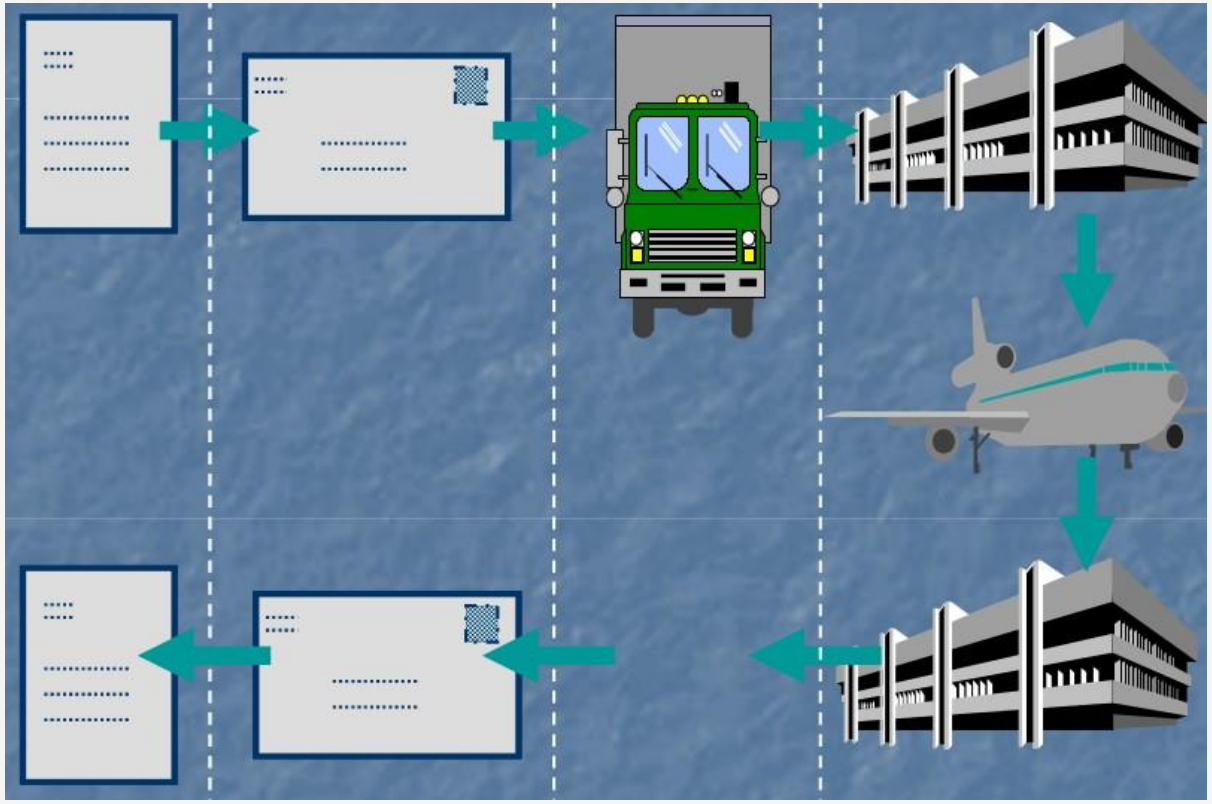
What is Layering?

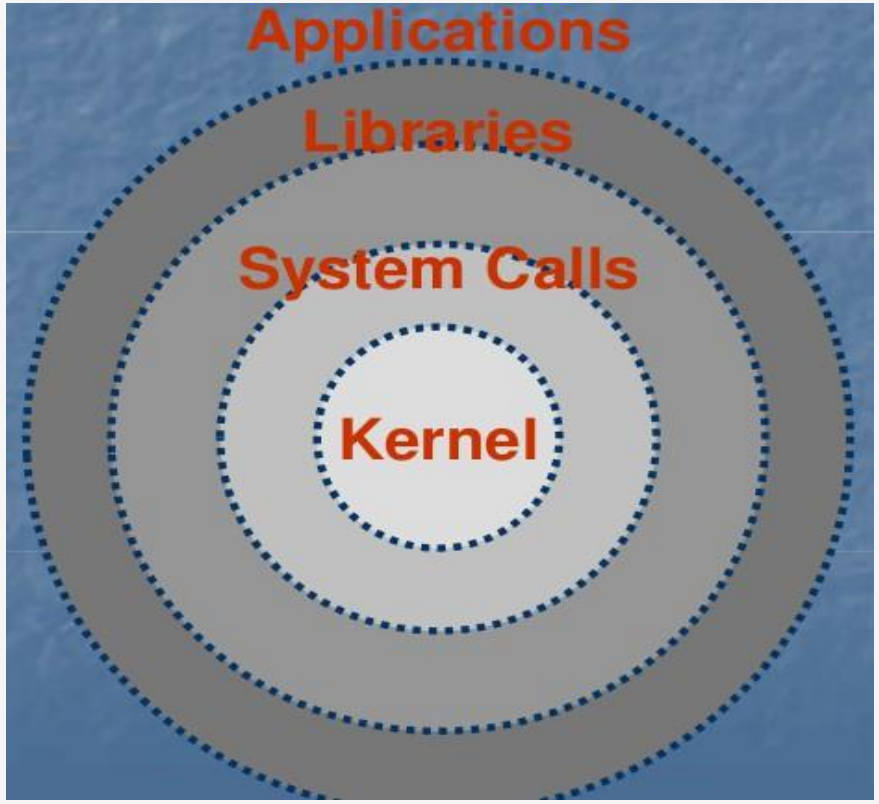
A technique to organize a network system into a succession of logically distinct entities, such that the service provided by one entity is solely based on the services provided by the previous (lower level) entity.

Why Layering?

- Solving all the problems at once is difficult
- It's a good idea to divide problems or functions into several sets
- Address the problem sets separately

Layered Architecture





OSI Reference Model

- The **International Standards Organization (ISO)** proposal for the standardization of the various protocols used in computer networks (specifically those networks used to connect open systems) is called the **Open Systems Interconnection Reference Model**, or simply the **OSI model.**

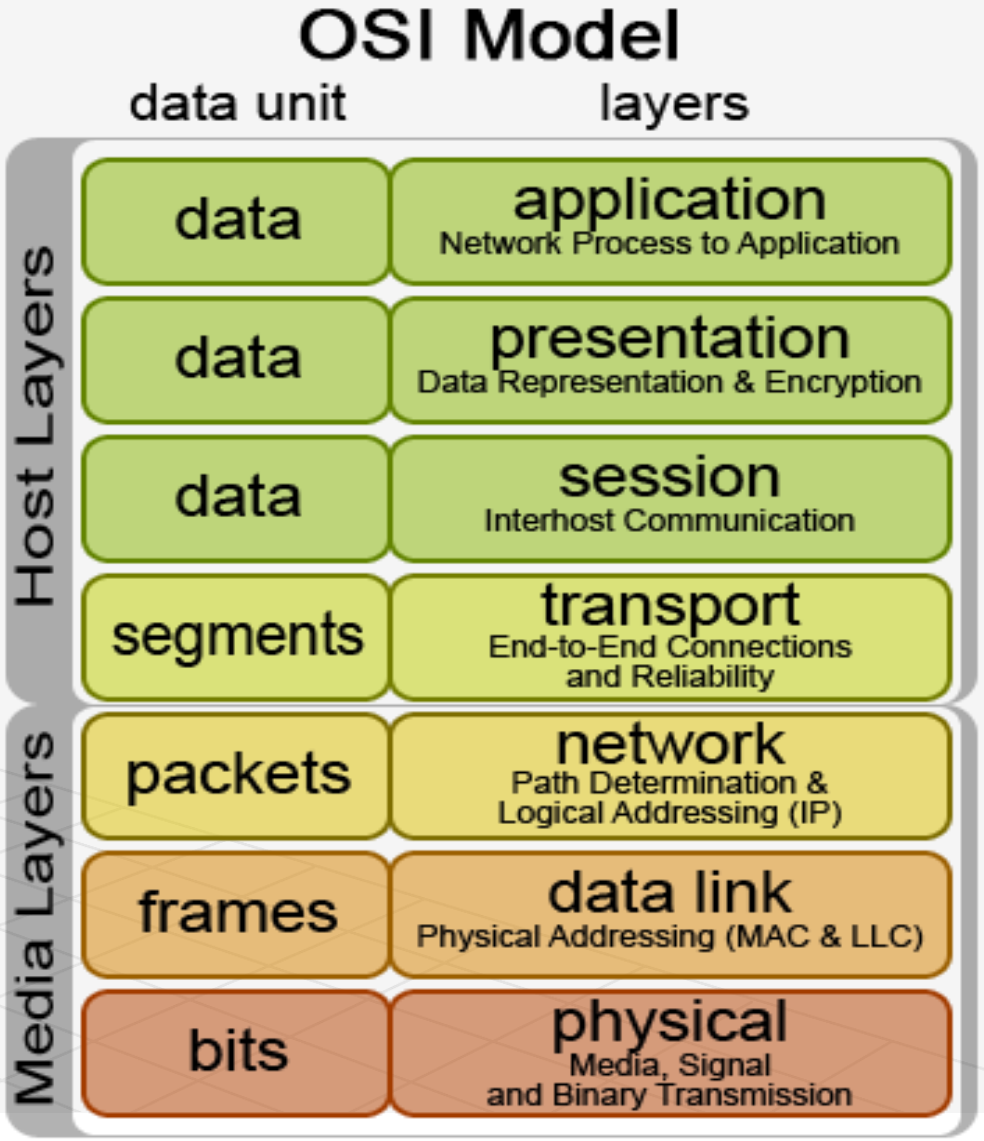
- In 1970's the ISO undertook to develop this standard and the first standard of the **7 layer architecture** came in 1974

- Although the OSI model is a just a model (not a specification), it is generally regarded as the most complete model (popular network protocol suites in use today were developed before the OSI model was defined - APANET 1969 & TCP/IP 1974).

OSI Model

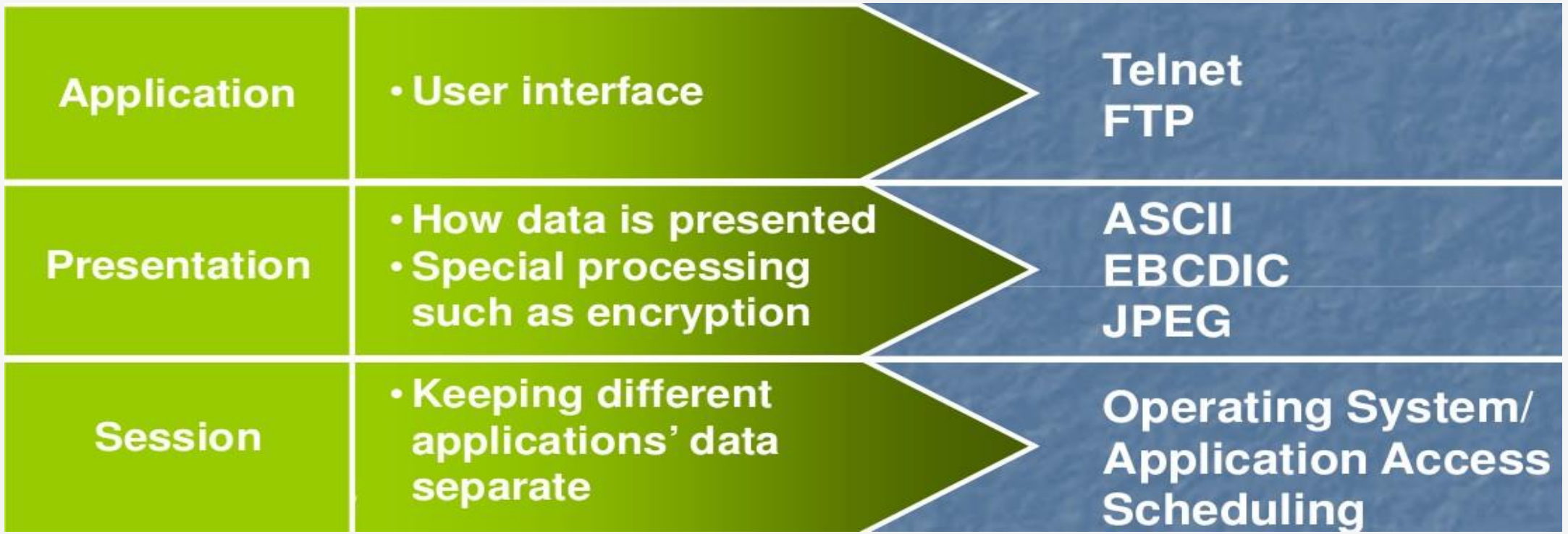
Open Systems Interconnection (OSI) model

- ✓ Application Layer (7)
- ✓ Presentation Layer (6)
- ✓ Session Layer (5)
- ✓ Transport Layer (4)
- ✓ Network Layer (3)
- ✓ Data Link Layer (2)
- ✓ Physical Layer (1)



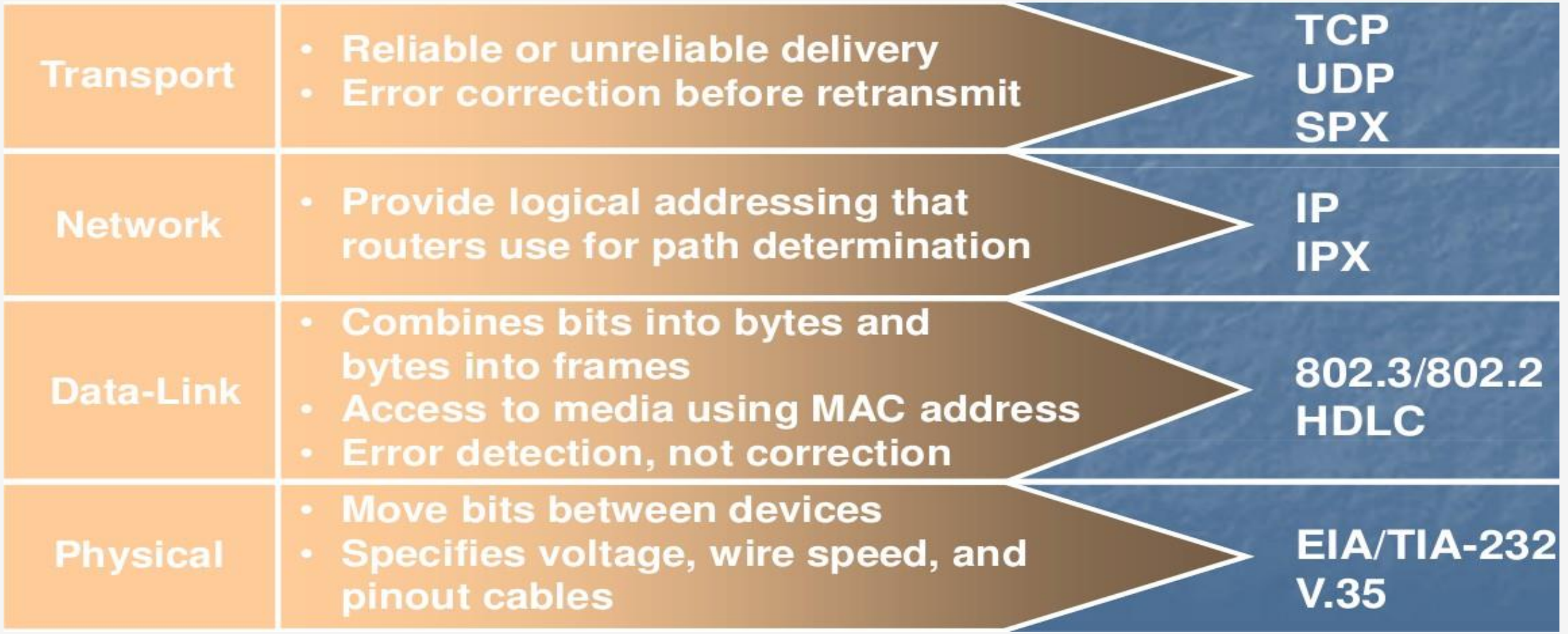
OSI Model (cont.)

role of the upper layers

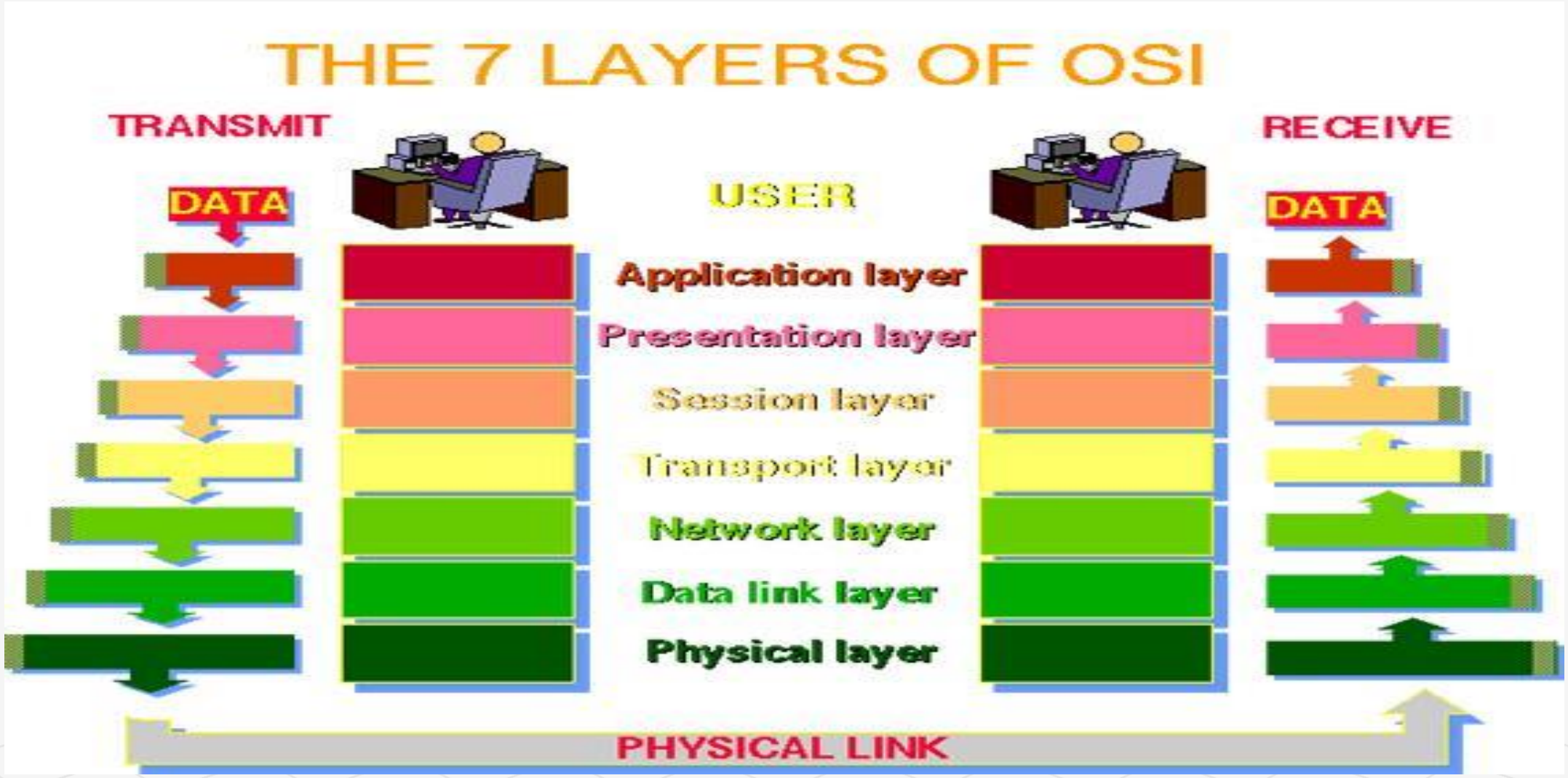


OSI Model (cont.)

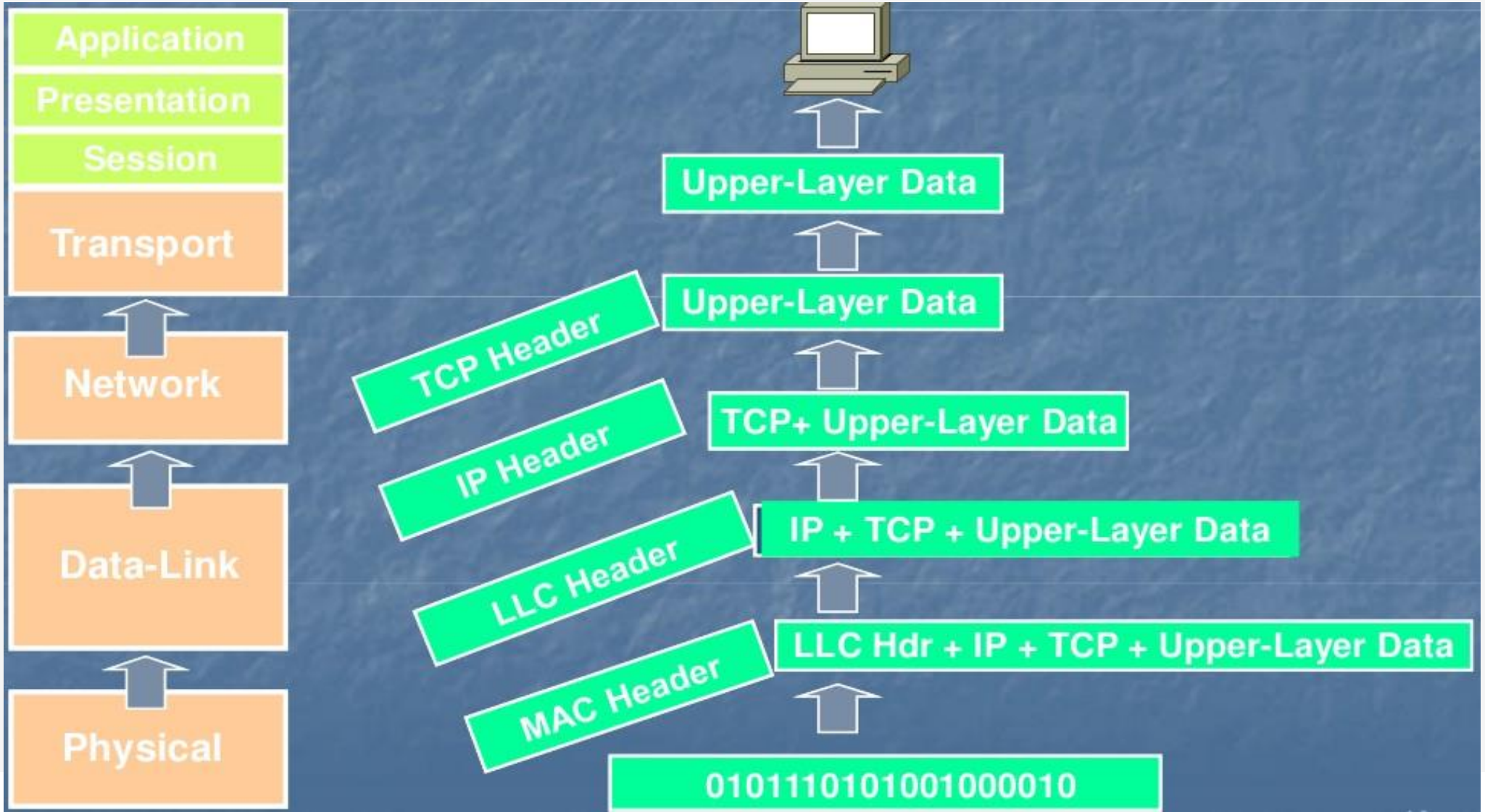
role of the lower layers



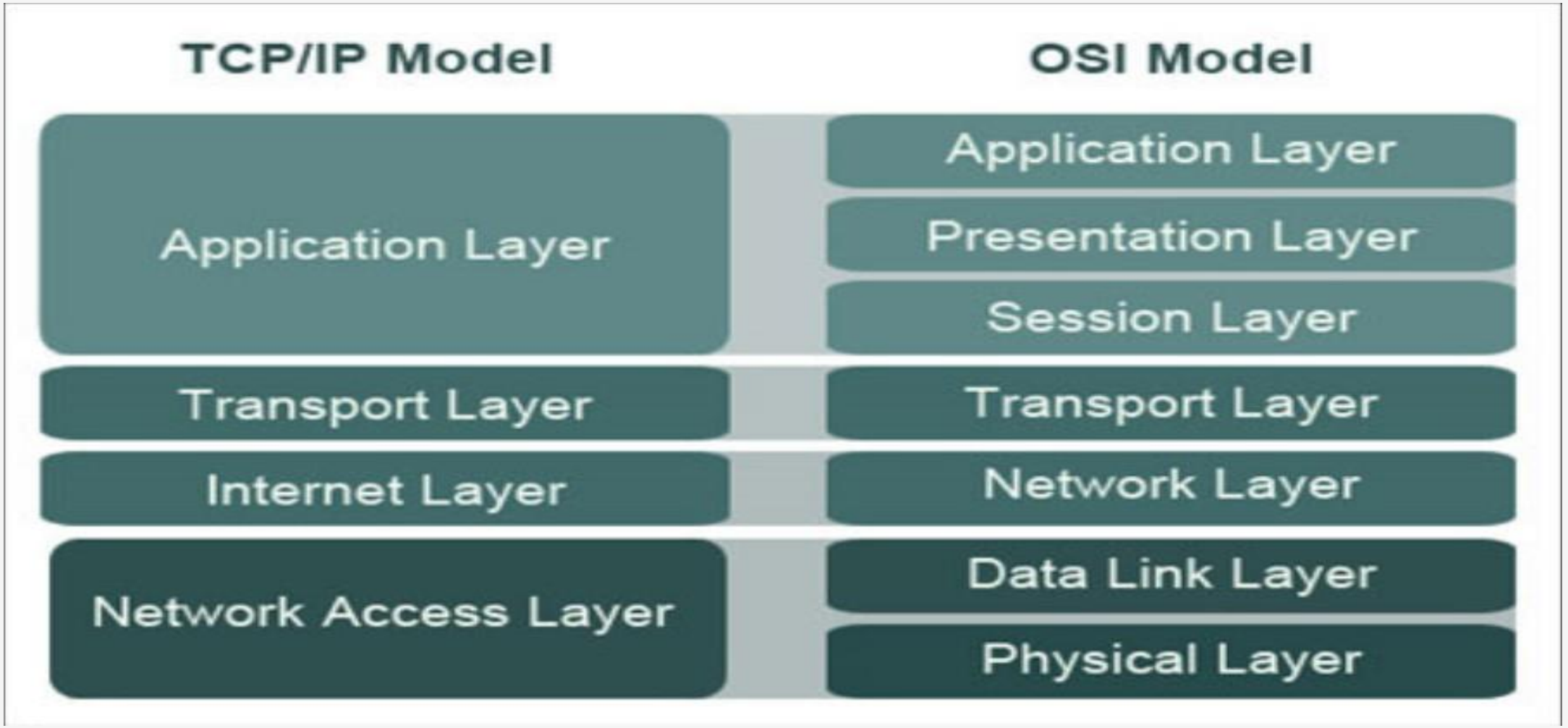
Lecture -1 Outline



De-encapsulating Data



OSI model vs TCP/IP model

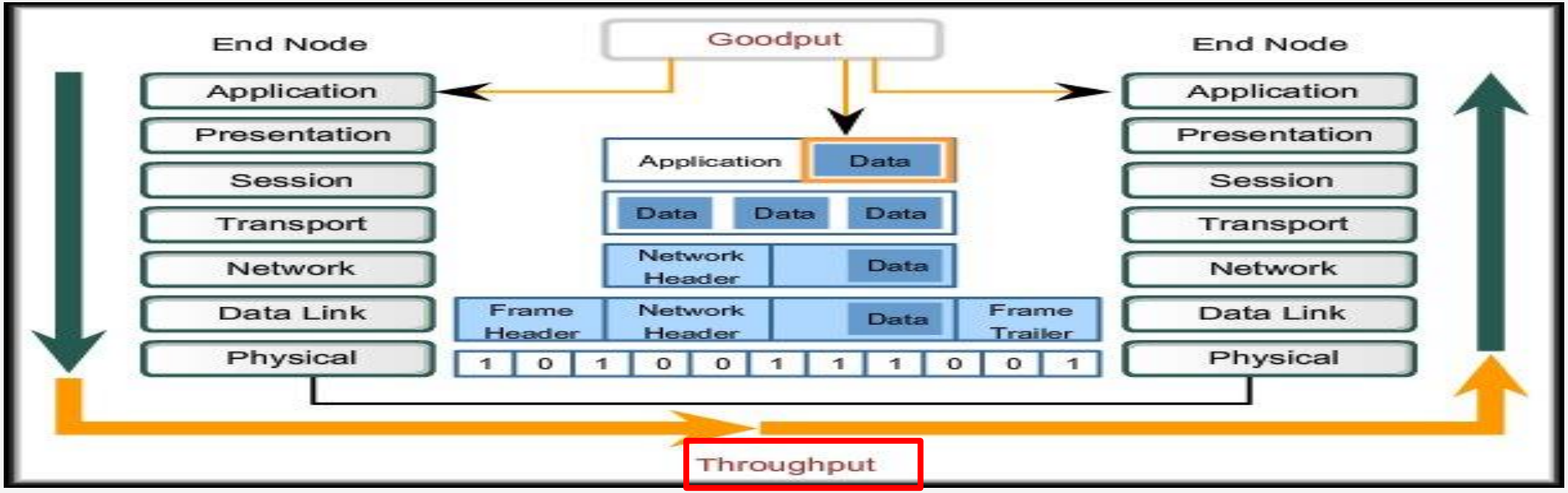


Data Carrying Capacity

Unit of Bandwidth	Abbreviation	Equivalence
Bits per second	bps	1 bps = fundamental unit of bandwidth
Kilobits per second	kbps	1 kbps = 1,000 bps = 10^3 bps
Megabits per second	Mbps	1 Mbps = 1,000,000 bps = 10^6 bps
Gigabits per second	Gbps	1 Gbps = 1,000,000,000 bps = 10^9 bps
Terabits per second	Tbps	1 Tbps = 1,000,000,000,000 bps = 10^{12} bps

- **Bandwidth (Theoretical):**
  - ✓ The capacity of a medium to carry data in a given amount of time.
  - ✓ Takes into account the physical properties of the medium and the signaling method.

Data Carrying Capacity

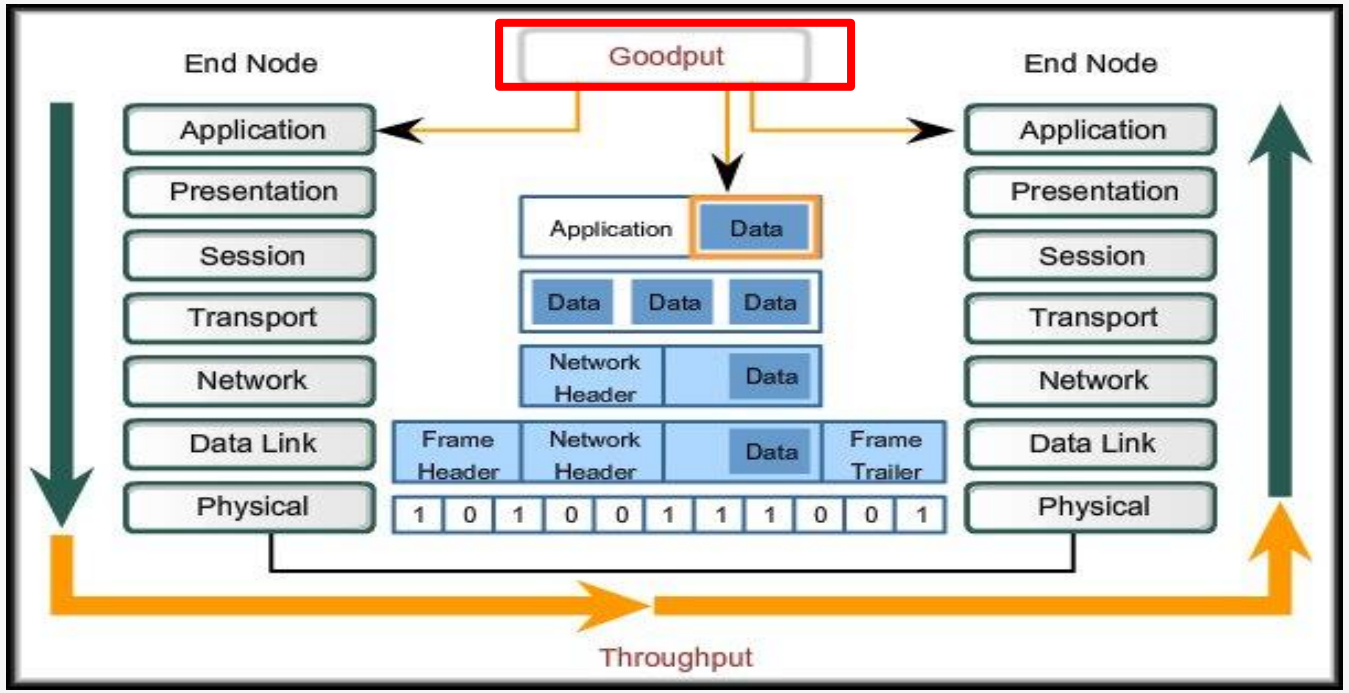


Throughput (Practical):

- Transfer rate of data over the medium.
- Factors affecting throughput:

  Amount and type of traffic, number of devices.

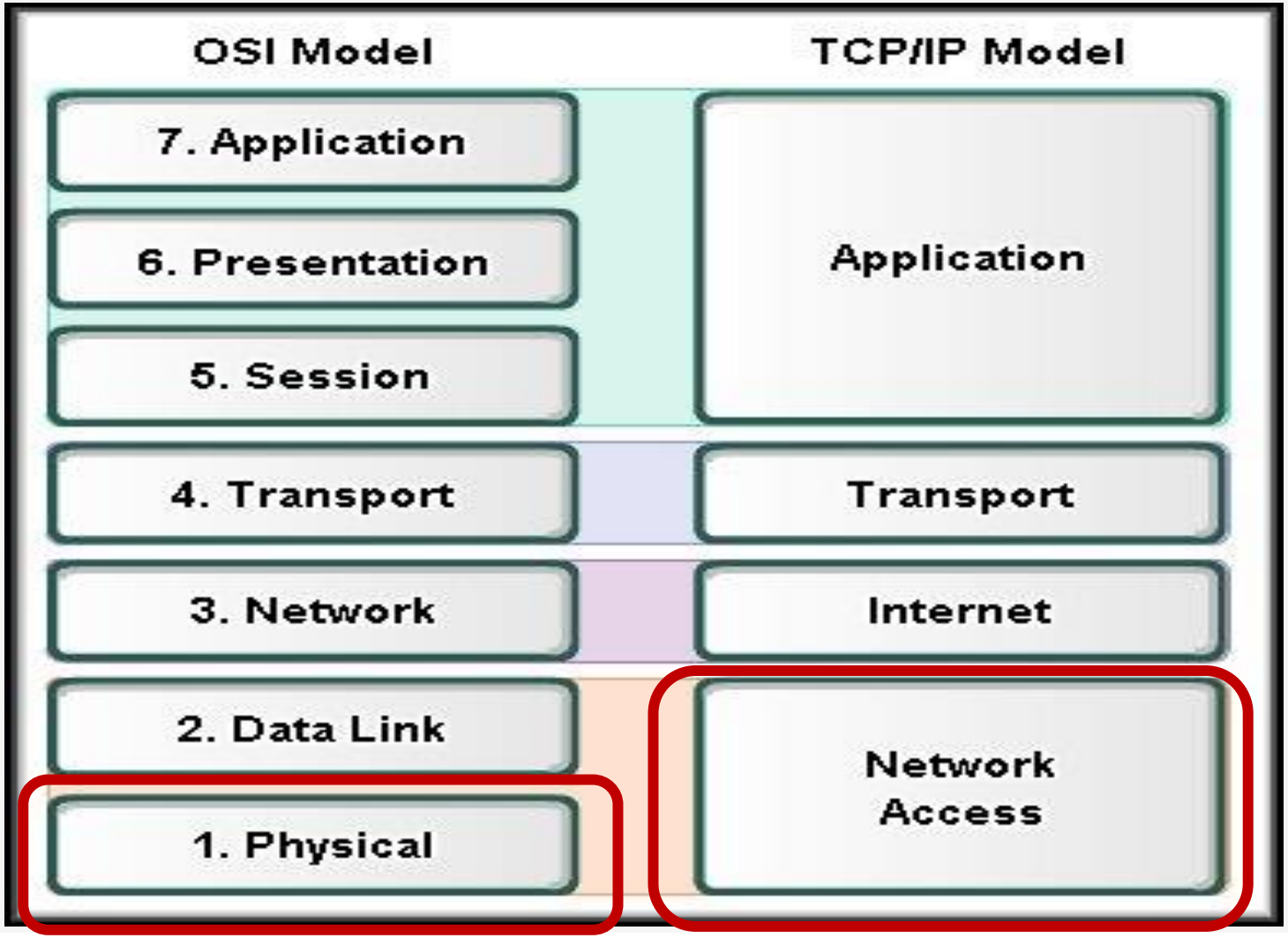
Data Carrying Capacity



Goodput (Qualitative):

- ✓ Transfer rate of actual usable data bits.
- ✓ Throughput less the data protocol overhead, error corrections and retransmissions.

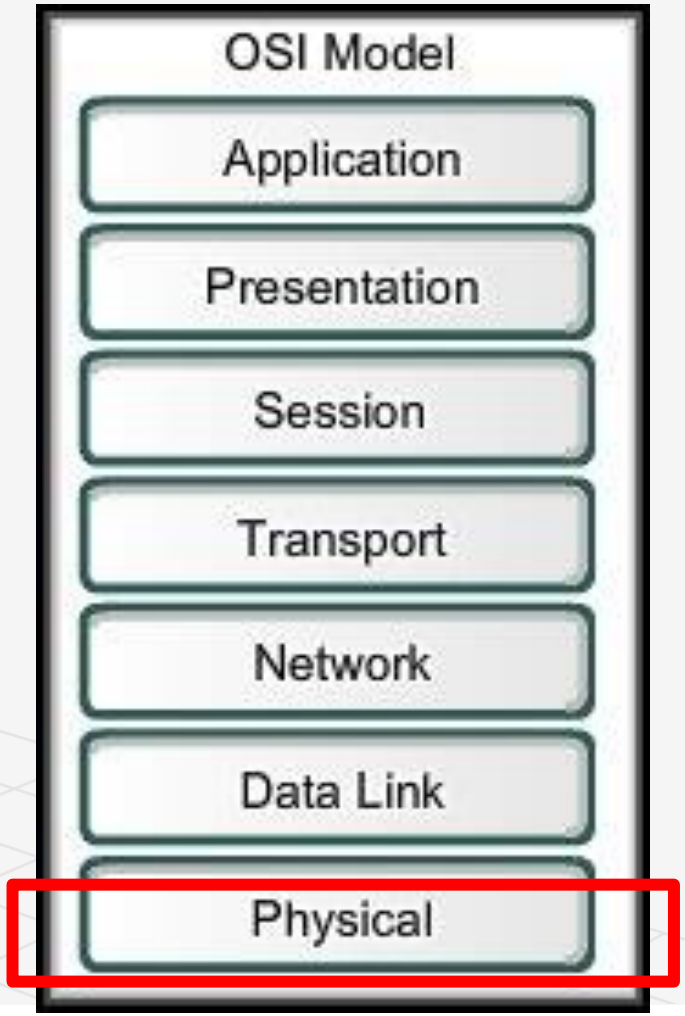
Physical layer



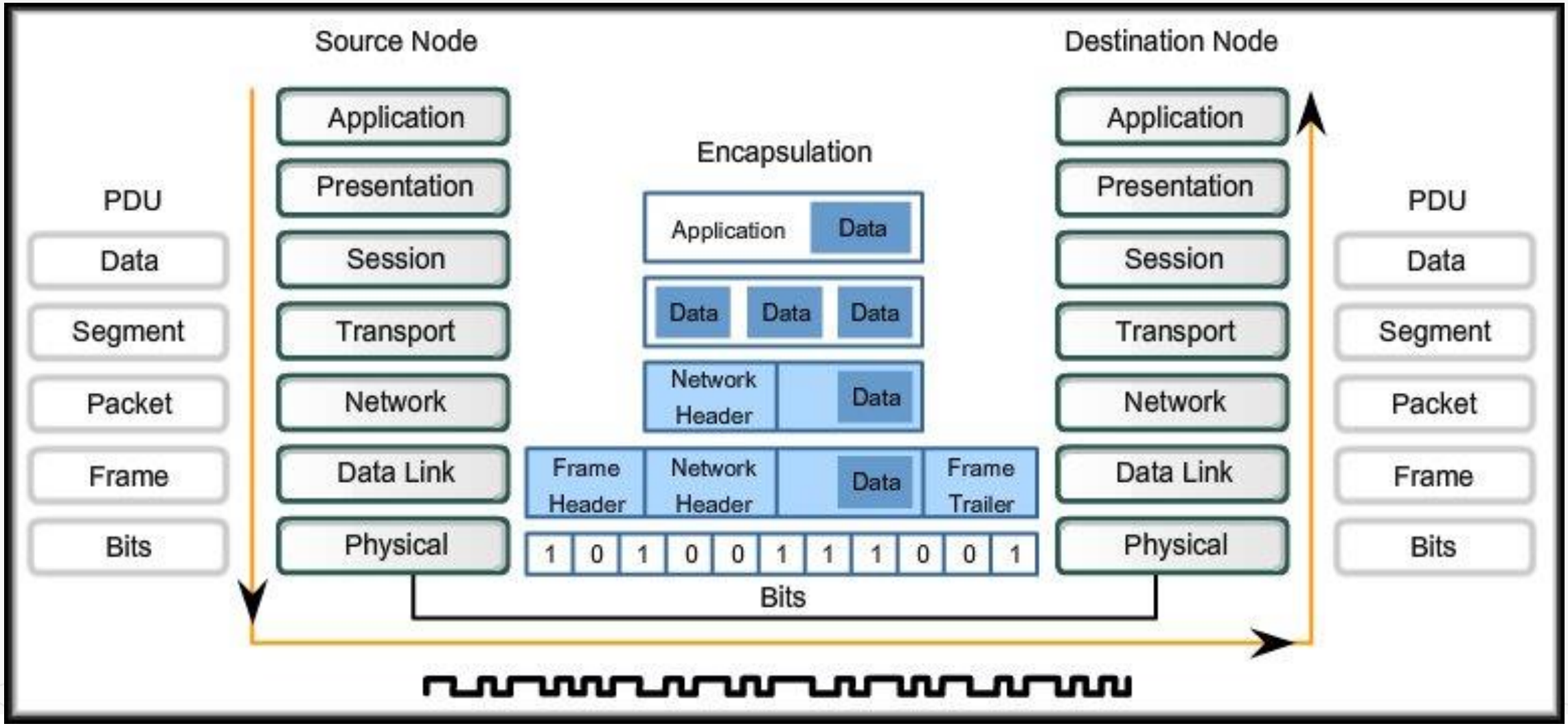
Purpose of the Physical Layer

.Requires:

- ✓ *Primary Purpose:*
  A representation of the bits of a frame on the media in the form of signals.
- ✓ The physical media and associated connectors.
- ✓ Encoding of data and control information.
- ✓ Transmitter and receiver circuitry on the network devices.



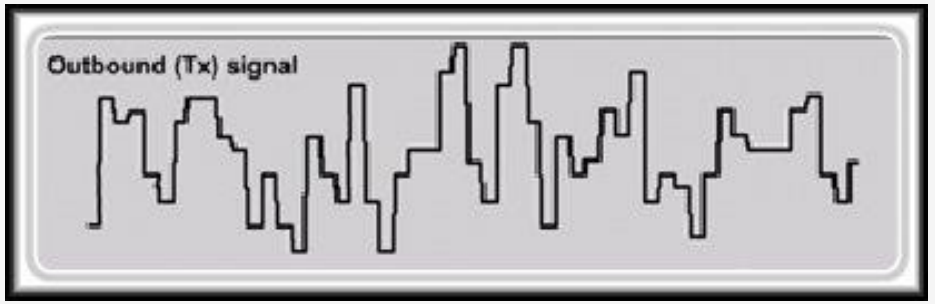
Purpose of the Physical Layer



Physical Layer Operation

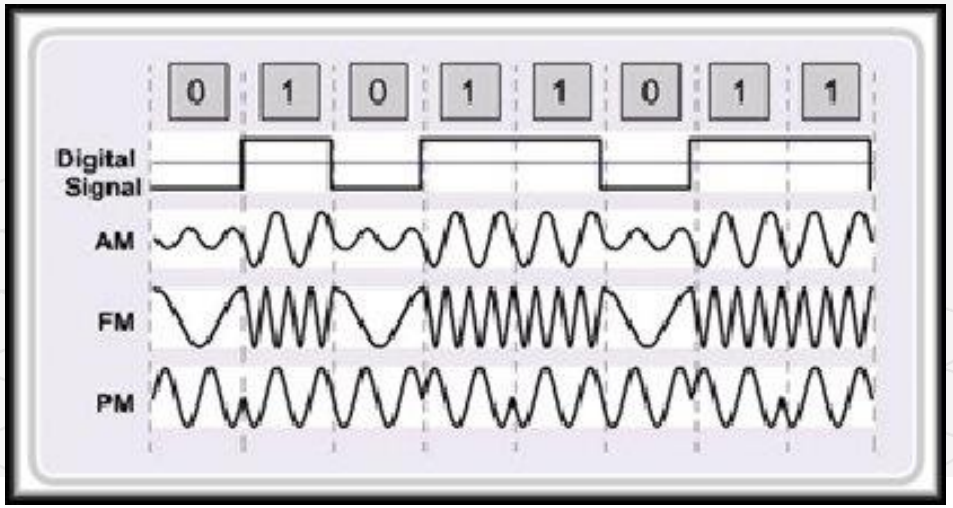
.Each medium has a unique method of representing bits (signaling):

Copper Cable



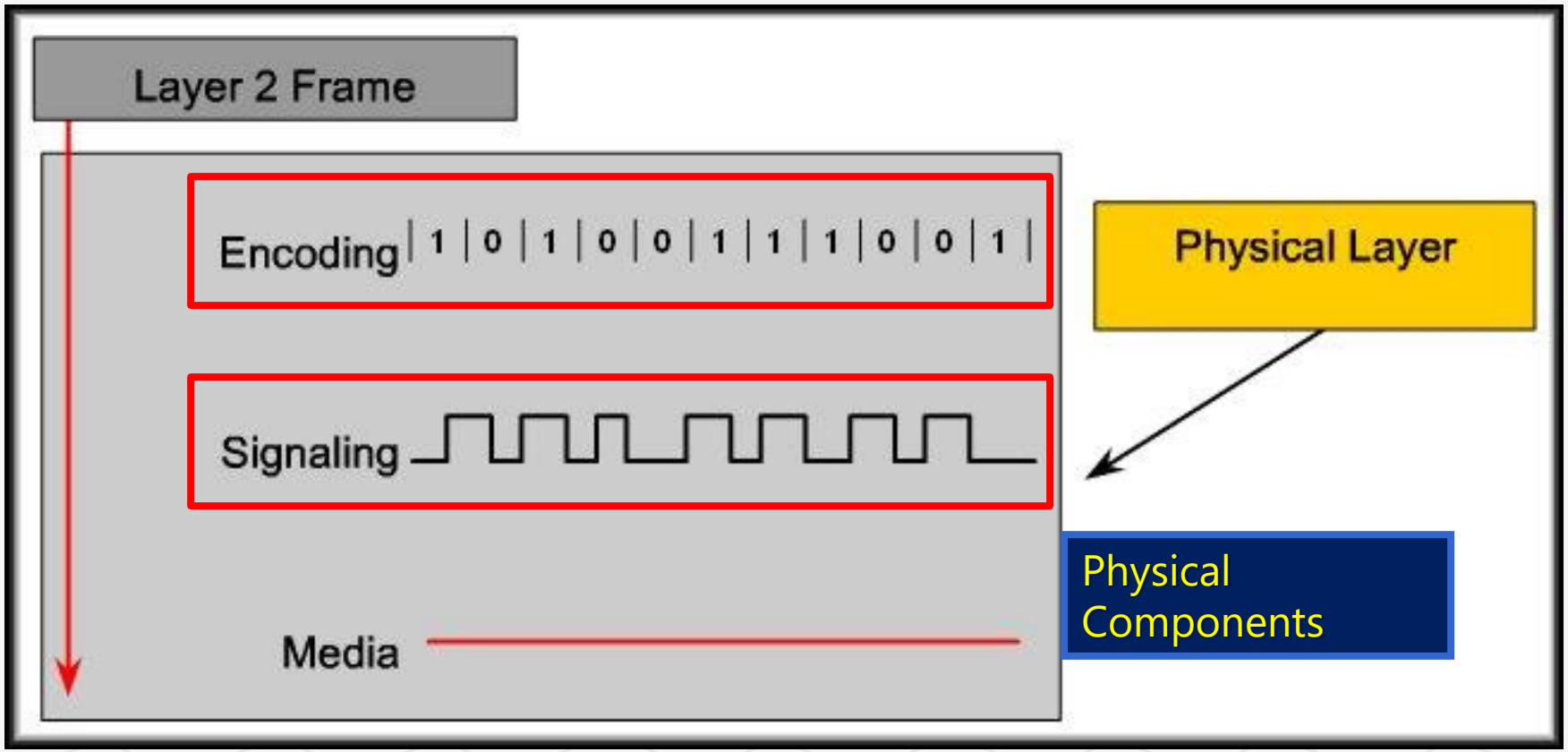
Fiber-optic

Wireless



Physical Layer Fundamental Principles

Three fundamental functions:



Physical Media

❖ Properties

- bandwidth
- delay
- cost
- ease of installation
- maintenance, etc

❖ Media

- guided (wire-line)
- unguided (wireless) - signal is always analog

❖ Design Factors

- Bandwidth - Higher bandwidth gives higher data rate
- Transmission impairments
- Interference
- Number of receivers - In guided media more receivers (multi-point) introduce more attenuation

Guided Transmission Media

- Twisted Pair
- Coaxial cable
- Optical fiber

Types of Physical Media

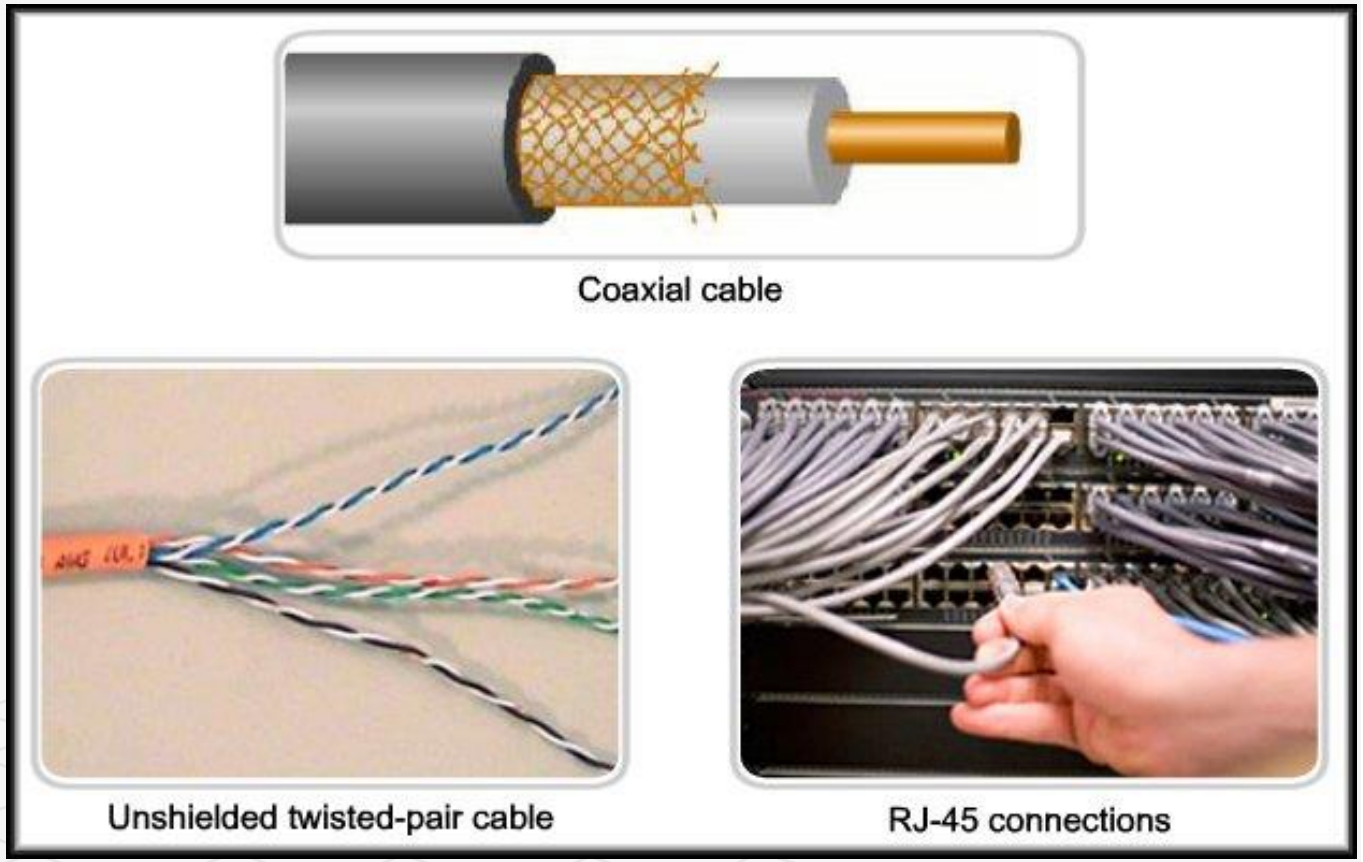
Specification	Media	Maximum Segment Length	Connector
10BASE-T	CAT 3,4 or 5 UTP (4 pair)	100m	RJ-45
100BASE-TX	CAT 5 UTP (2 pair)	100m	RJ-45
100BASE-FX	62.5/125 multimode fiber	2km	
1000BASE-CX	STP	25m	RJ-45
1000BASE-T	CAT 5 UTP (4 pair)	100m	RJ-45
1000BASE-SX	62.5/50 multimode fiber	62.5 – 275m 50 – 550m	
1000BASE-LX	62.5/50 multimode 9-micron single-mode fiber	62.5/50 – 550m 9 –10 km	
1000BASE-ZX	9-micron single-mode fiber	70km	
10GBASE-ZR	9-micron single-mode fiber	80km	

Copper Media

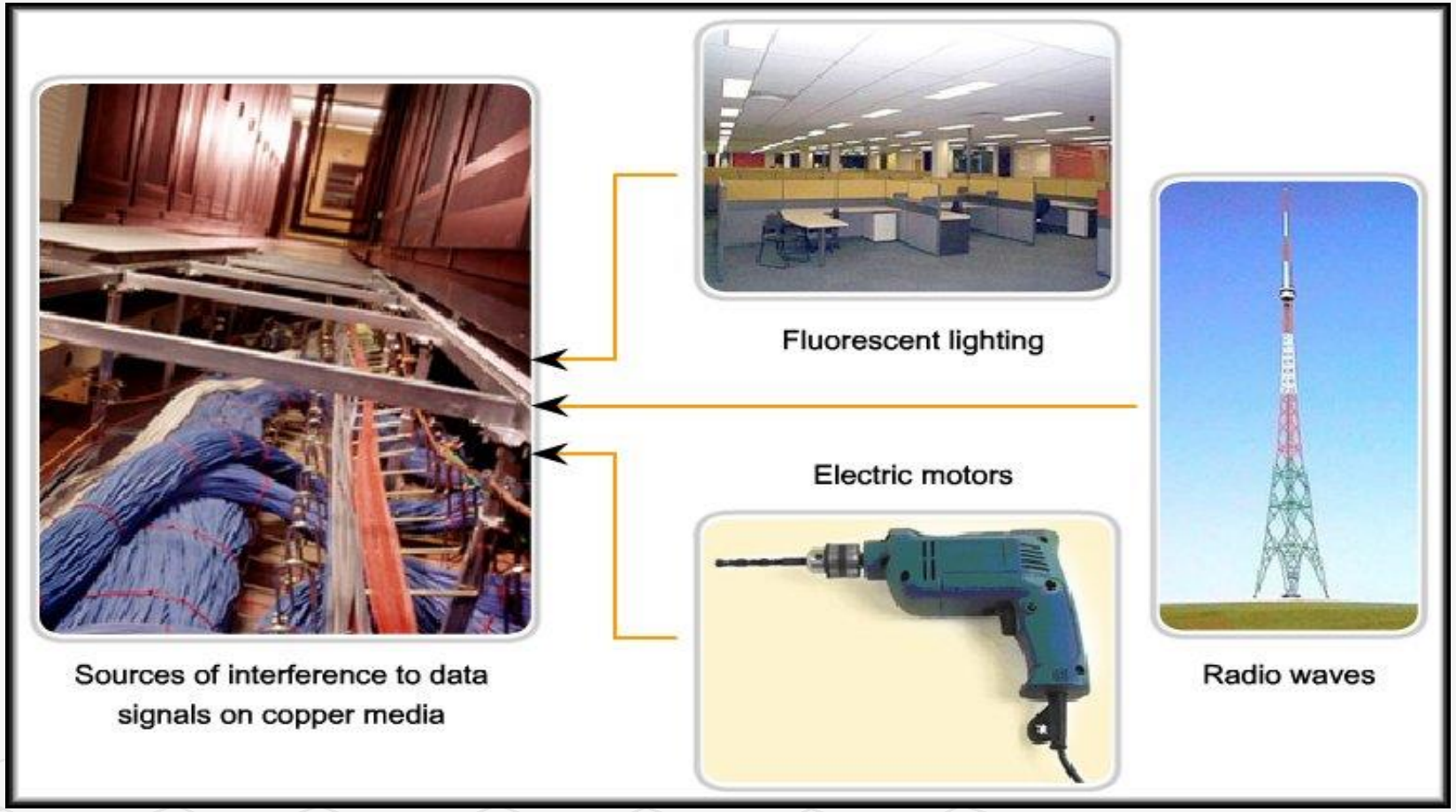
Most common means for connecting network devices.

Standards been defined for:

- ✓ Type of copper cabling
- ✓ Bandwidth
- ✓ Type of connector
- ✓ Pin out and colour codes of media connections
- ✓ Maximum distance



Copper Media

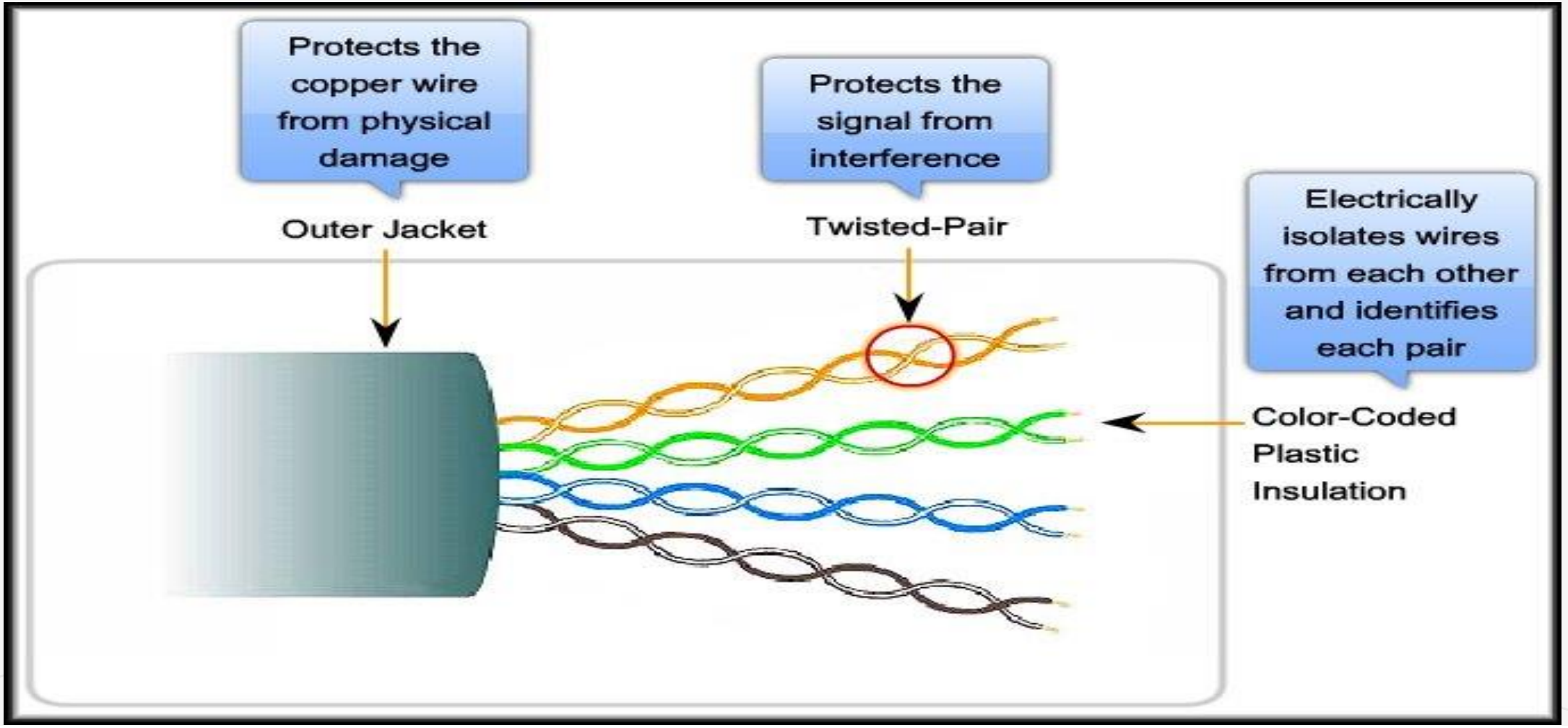


Interference:

Data travels as electrical pulses.

Copper Media

Unshielded Twisted-Pair (UTP) Cable



Twisted Pair – Applications

- ✓ **Telephone network**

  Between house and local exchange (subscriber loop)

- ✓ **Within buildings**

  To private branch exchange (PBX)

- ✓ **For local area networks (LAN)**

  10Mbps or 100Mbps

Twisted Pair – Pros & Cons

- ✓ Cheap
- ✓ Easy to work with
- ✓ Low data rate
- ✓ Short range

Twisted Pair – Transmission Characteristics

- **Analog**

  Amplifiers are used for long distances

- **Digital**

  Use either analog or digital signals

  repeaters are used for long distances

- **Limited distance**
- **Limited bandwidth**
- **Limited data rate**
- **Susceptible to interference and noise**

Q1: What is the type of connector used in twisted pair?

Unshielded and Shielded TP

Unshielded Twisted Pair (UTP) (do not have shielding serving them to reduce interference)

- Ordinary telephone wire
- Cheapest
- Easiest to install
- Suffers from external EM interference

Shielded Twisted Pair (STP)

- Metal braid or sheathing that reduces interference
- More expensive
- Harder to handle (thick, heavy)

Copper Media

Unshielded Twisted-Pair (UTP) Cable:

TIA/EIA standards include:

- Cable types
- Cable lengths
- Connectors
- Cable Termination
- Methods of testing

IEEE assigns categories based on bandwidth performance.

- Cat 5 – up to 100-megabit
- Cat 5e – full-duplex up to 1000-megabit (gigabit)
- Cat 6 – up o 250MHz, recommended standard for gigabit

UTP Categories

Category 7 cable

- ✓ Cat 7 features even more strict specifications for crosstalk and system noise than Cat 6. To achieve this, shielding has been added for **individual wire** pairs and the cable as a whole.

- ✓ The Cat 7 cable standard has been created to allow **10 Gigabit Ethernet over 100 m** of copper cabling. The cable contains four twisted copper wire pairs, just like the earlier standards. Cat 7 cable is rated for transmission frequencies of up to **600 MHz**.

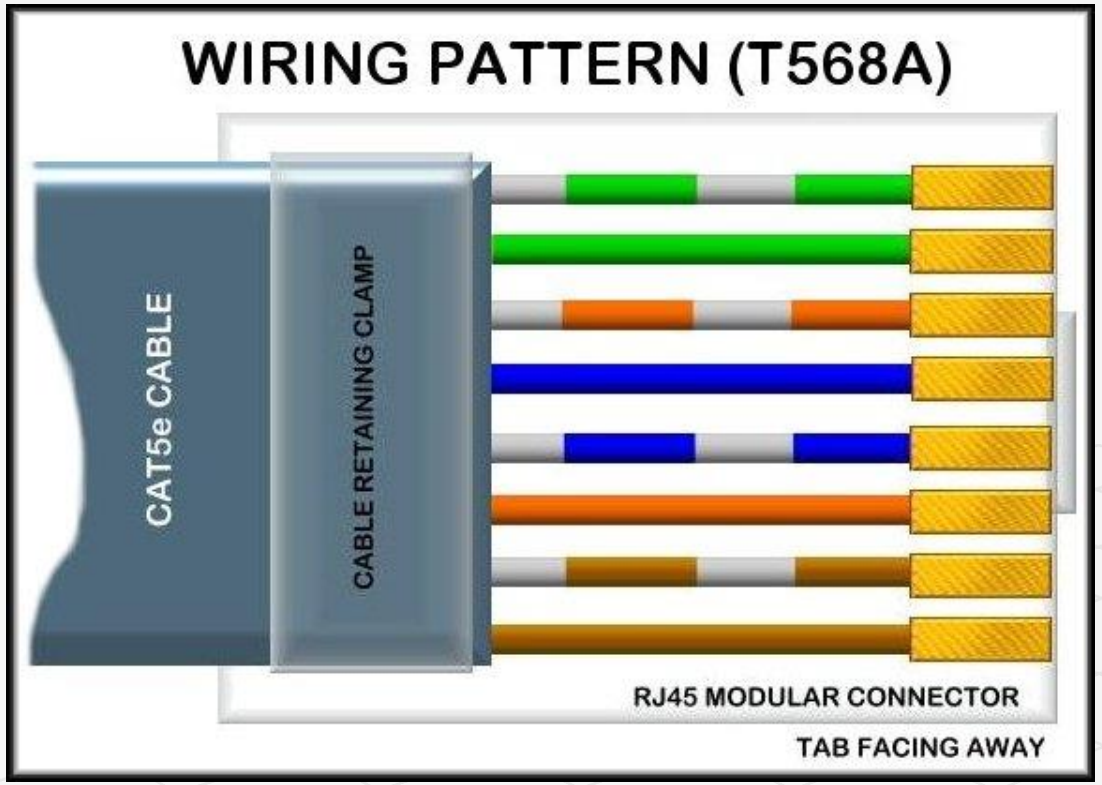
- ✓ **Category 7a** is defined at frequencies up to **1000 MHz**, suitable for multiple applications in a single cable. Simulation results have shown that **40 Gigabit** Ethernet is possible at 50 meters and

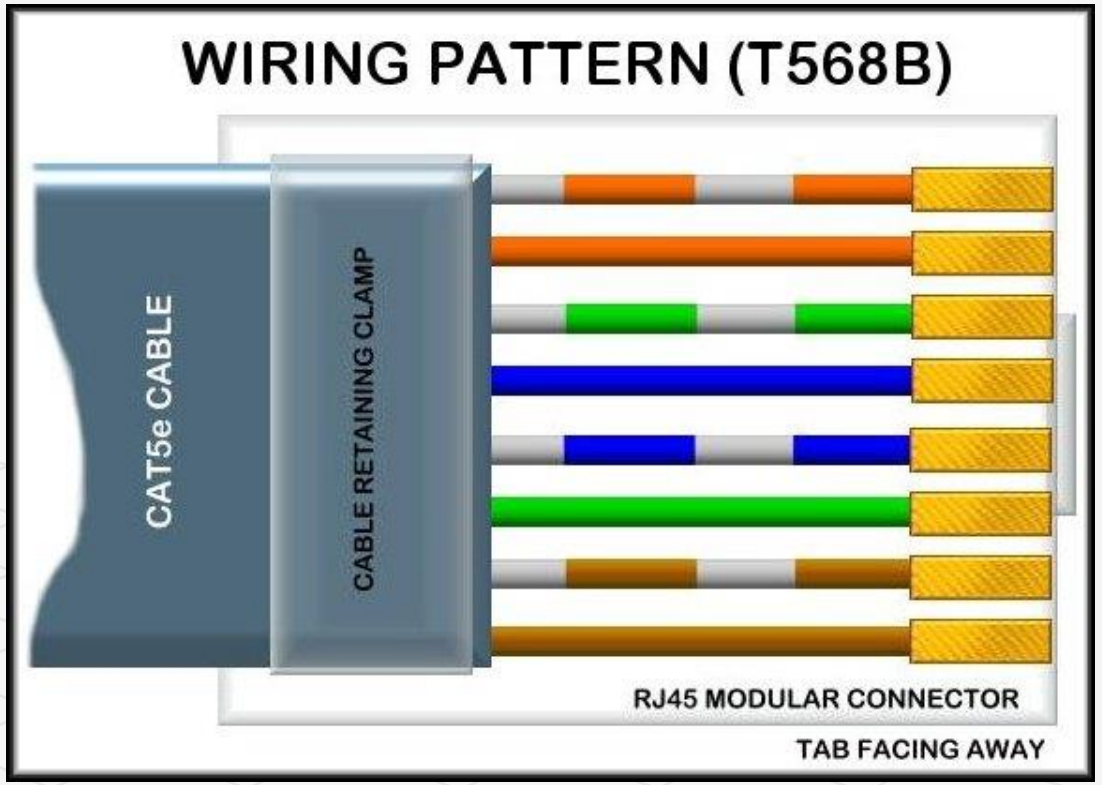
  100 Gigabit Ethernet is possible at 15 meters.

Copper Media

Wiring Patterns:

There are two specific TIA/EIA standard wiring patterns:





Copper Media

UTP Cable Types:

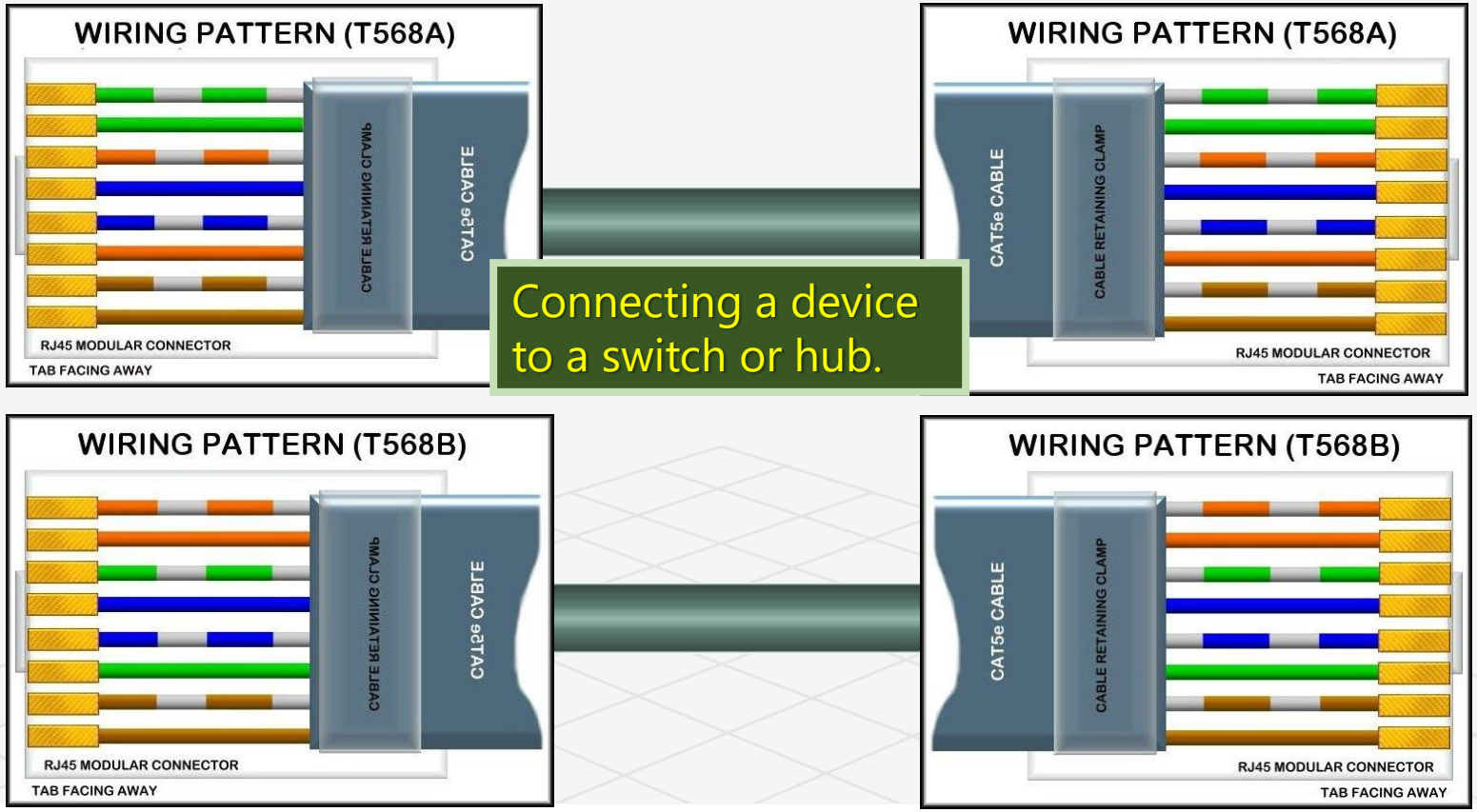
Different situations may require UTP cables to be wired according to different wiring patterns:

- Ethernet Straight-through
- Ethernet Crossover
- Rollover

Copper Media

Ethernet Straight-through:

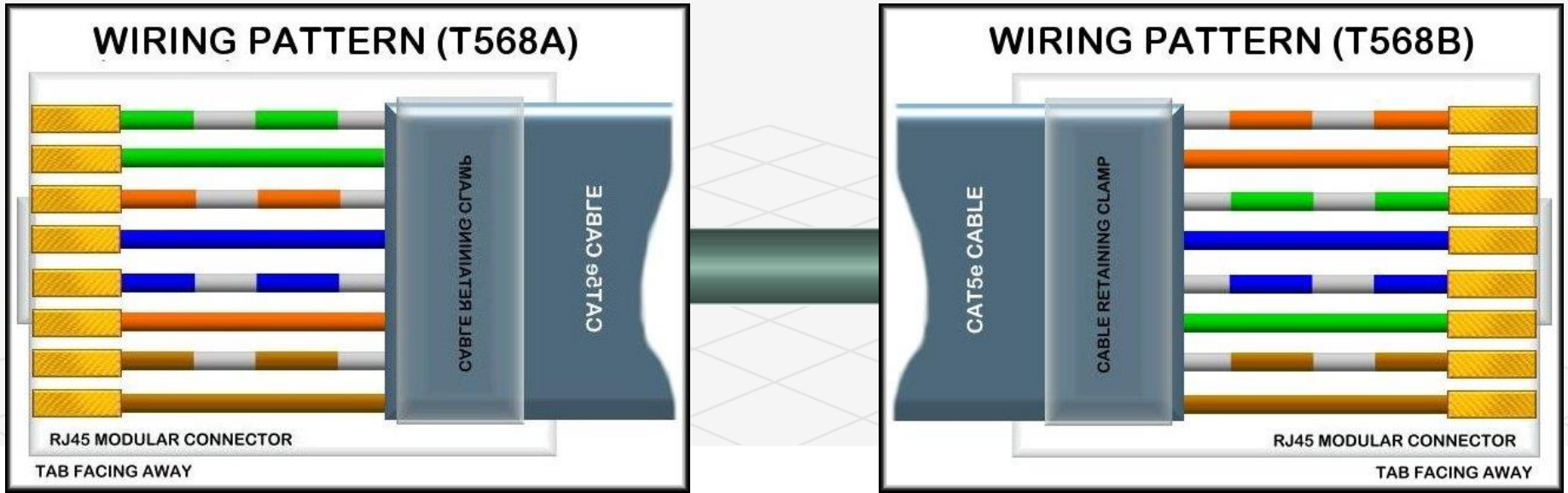
T568A or T568B may be used as long as the same pattern is used at both ends of the cable.



Copper Media

Ethernet Crossover:

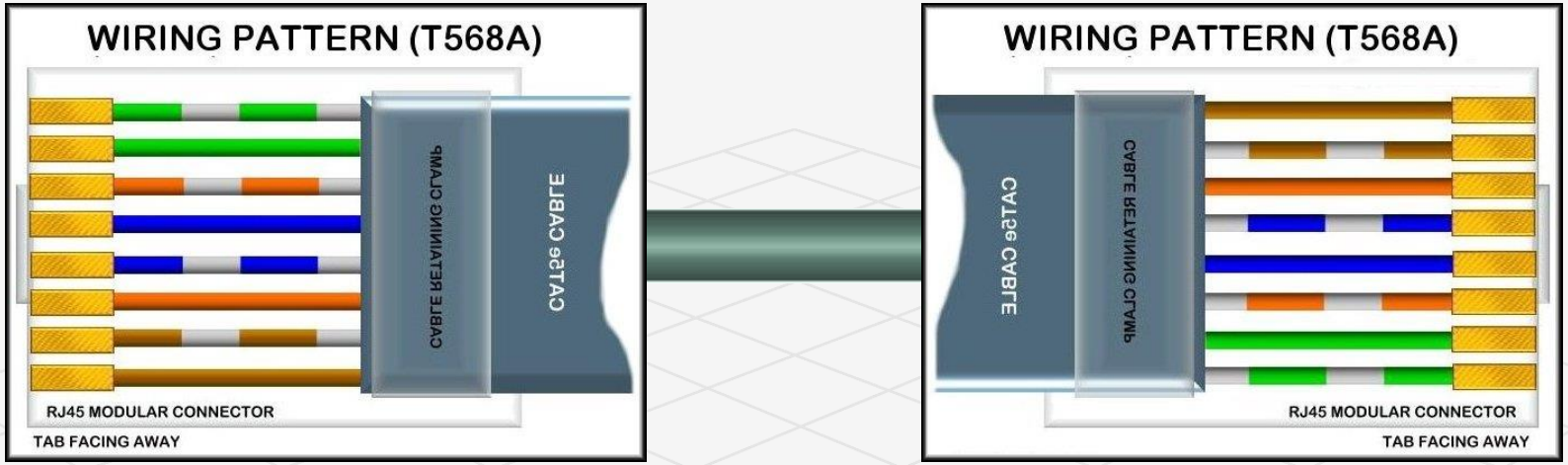
- T568A and T568B are used at either end of the cable.
- Connecting two workstations together.
- Connecting two networking devices.
  - Switch to a switch
  - Router to a router



Copper Media

Ethernet Rollover:

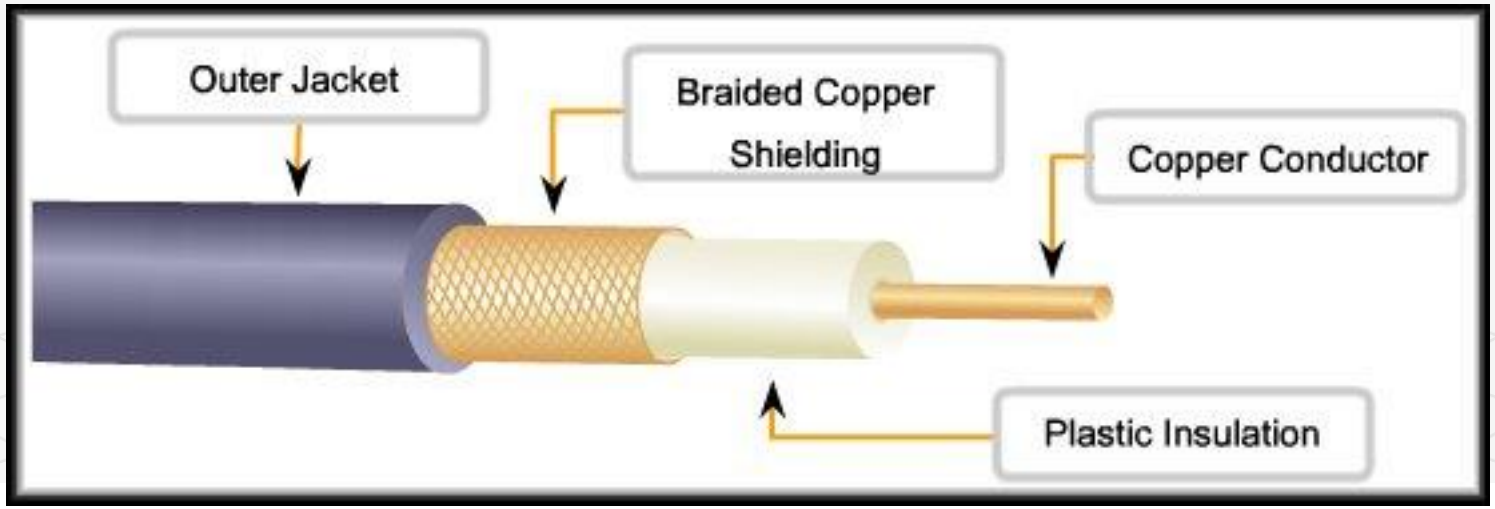
- Cisco proprietary.
- Connecting a workstation serial port to a Cisco networking device console port using a nine-pin adapter.
- T568A or T568B may be used.



Copper Media

Other Copper Cable Types:

- Coaxial Cable:
  - Used in wireless and cable access technologies.
    - Attach antennas to wireless devices.
    - Transmitting television channels.
    - Can run longer distances than STP or UTP.

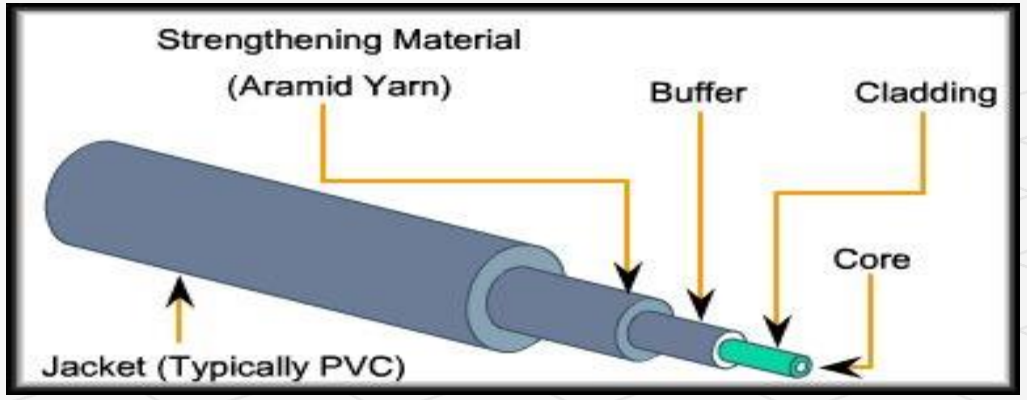


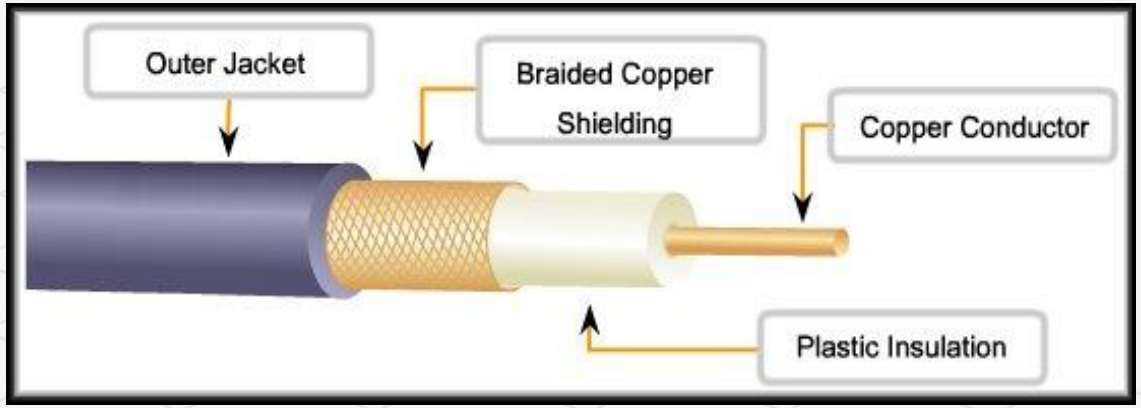
Copper Media

Other Copper Cable Types:

- Hybrid Fiber-Coax (HFC):
  - Cable structure used to provide two way communication over a coaxial cable (i.e. cable connection to the Internet)

    Coaxial at the destination but multi-fiber optical cable to the provider.

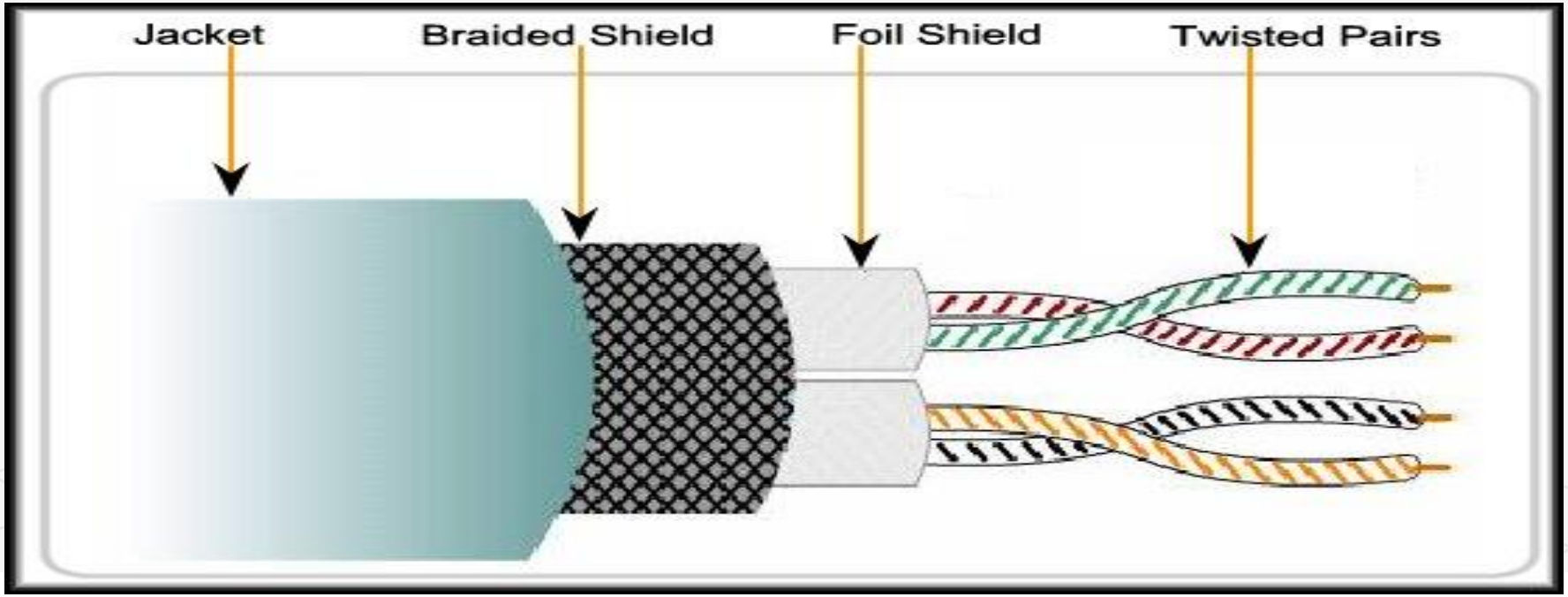




Copper Media

Other Copper Cable Types:

- Shielded Twisted Pair (STP):
  - STP cable shields the entire bundle of wires within the cable as well as the individual wire pairs to provide better noise protection than UTP.



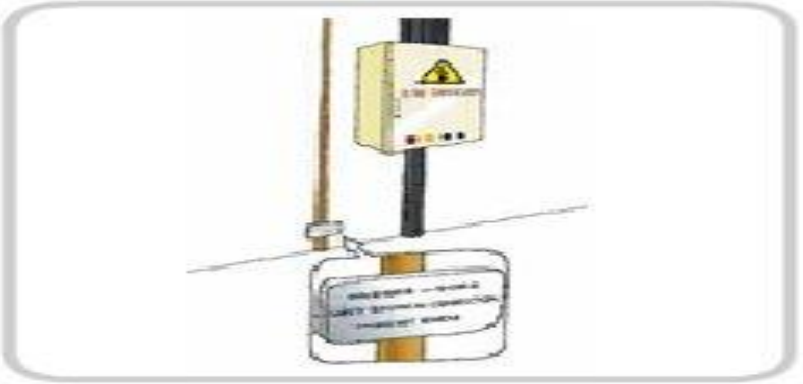
Copper Media

Copper Media Safety

The separation of data and electrical power cabling must comply with safety codes.

Cables must be connected correctly.

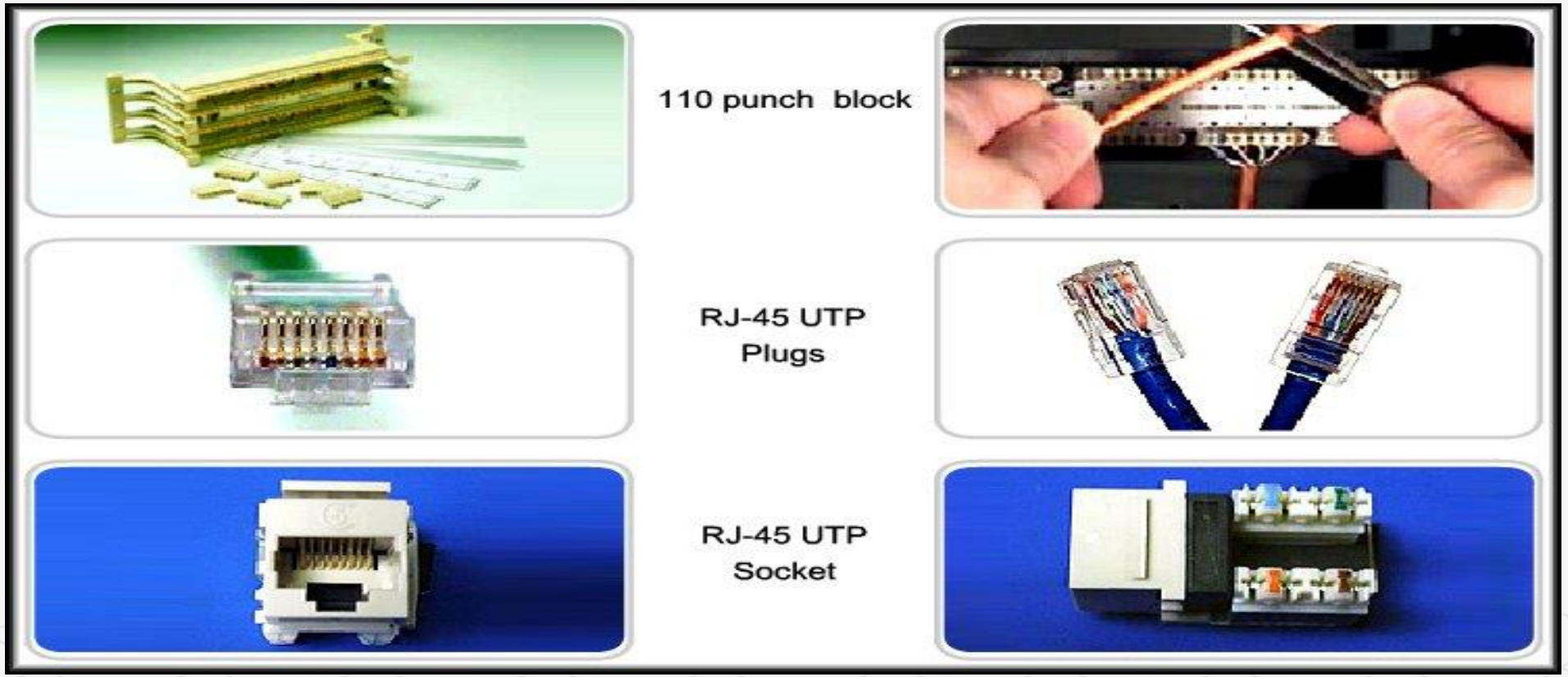
Installations must be inspected for damage.



Equipment must be grounded correctly.

Copper Media Connectors

While connectors may appear the same, they may be wired differently depending on the Physical Layer specification.



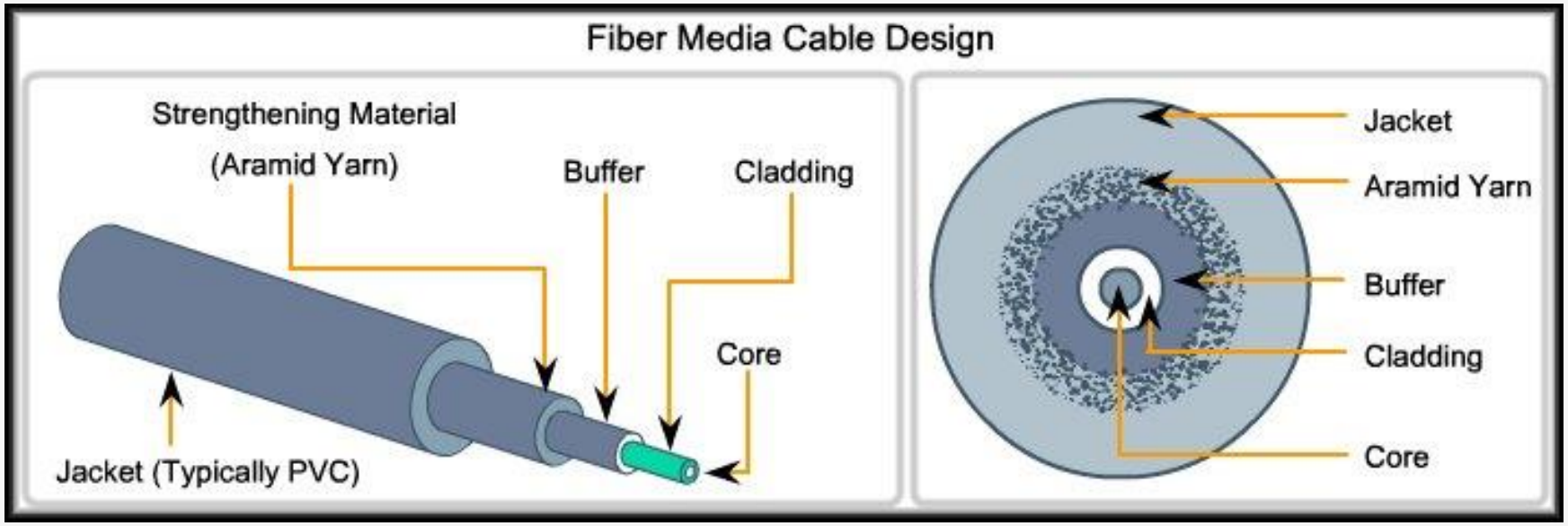
Fiber Media

- Many people in computer industry take enormous pride in how fast computer technology is improving.
- In 1981 IBM PC ran at a 4.77MHz clock speed, 20 years' later PCs could run 2 GHz clock speed.
- Same period wide area data communication went from 56 kbps to 1Gbps, a gain of more than a faster 125 per decade.

Optical transmission system has three key components:

- **The light source –** a pulse of light indicates a 1 bit and absence of light indicates 0 bit.
- **The transmission medium** – ultra-thin fiber of glass.
- **The detector** – generate an electronical pulse when light falls on it.

Fiber Media


Fiber Media Cable Design
Strengthening Material
(Aramid Yarn)
Buffer
Cladding
Core
Jacket (Typically PVC)
Jacket
Aramid Yarn
Buffer
Cladding
Core

Fiber Optics

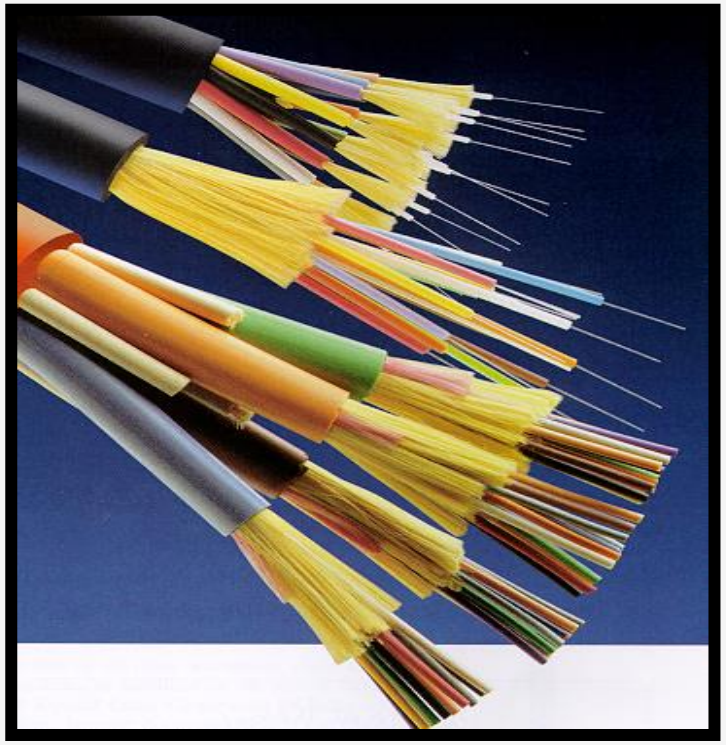
Benefits:

- Greater capacity : data rates of hundreds of Gbps
- Smaller size & weight
- Lower attenuation
- Electromagnetic isolation
- Greater repeater spacing

Optical Fiber (Cond)

Applications:

- Long-haul trunks
- Metropolitan trunks
- Rural exchange trunks
- Subscriber loops
- LANs



Characteristics:

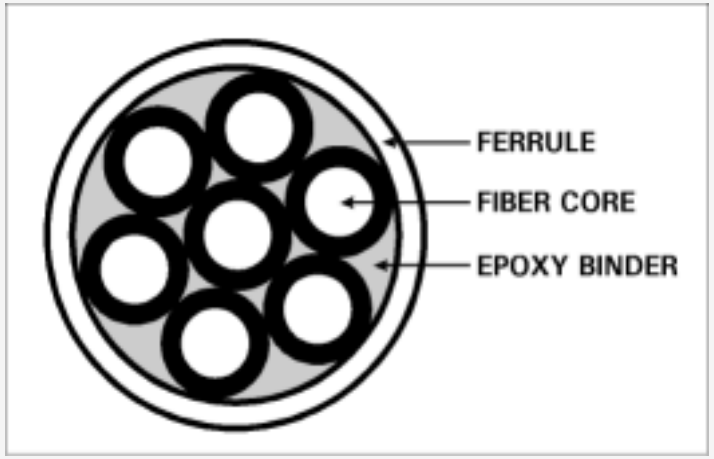
Act as wave guide for 1014 to 1015 Hz

- Portions of infrared and visible spectrum

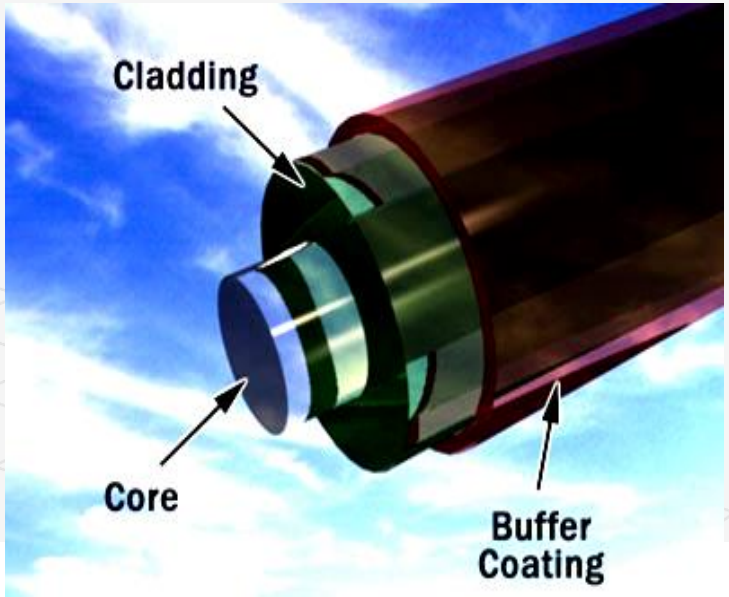
- ✓ **Wavelength Division Multiplexing**
- ✓ **Single-mode** – light only propagates in straight lines without bouncing, expensive, but can be used for long distance, core 8-10 microns
- ✓ **Multi-mode** – many different rays will be bouncing around at different angles, core 50-65 microns (Cladding ~125 microns)

Fiber Cables

- ✓ Silica based glass or plastic filaments are spun and packed into bundles of several hundreds or thousands. Bundles may be put together as rods or ribbons and sheets.
- ✓ These bundles are flexible and can be twisted and contorted to conduct light and images around corners
- ✓ The thin glass center of the fiber where the light travels is called the "**core**".
- ✓ The outer optical material surrounding the core that reflects the light back into the core is called the "**cladding**".
- ✓ In order to protect the optical surface from moisture and damage, it is coated with a layer of buffer coating.



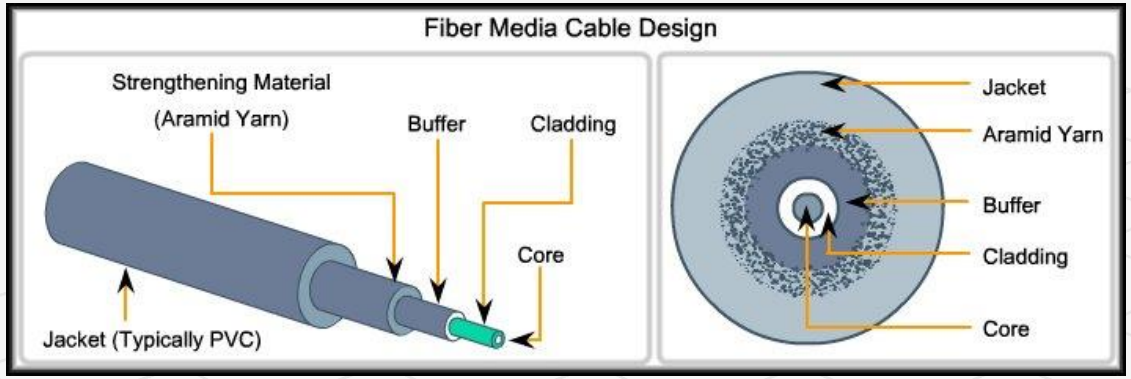
Cross section of a bundle

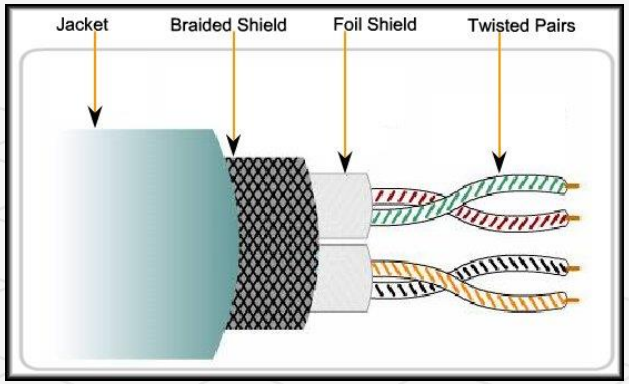


Fiber Media

Fiber vs Copper:

- More expensive (usually) than copper media over the same distance (but for a higher capacity).
- Different skills and equipment required to terminate and splice the cable infrastructure.
- More careful handling than copper media.
- Immune to electromagnetic interference.
- Much greater lengths than copper media (kilometers).

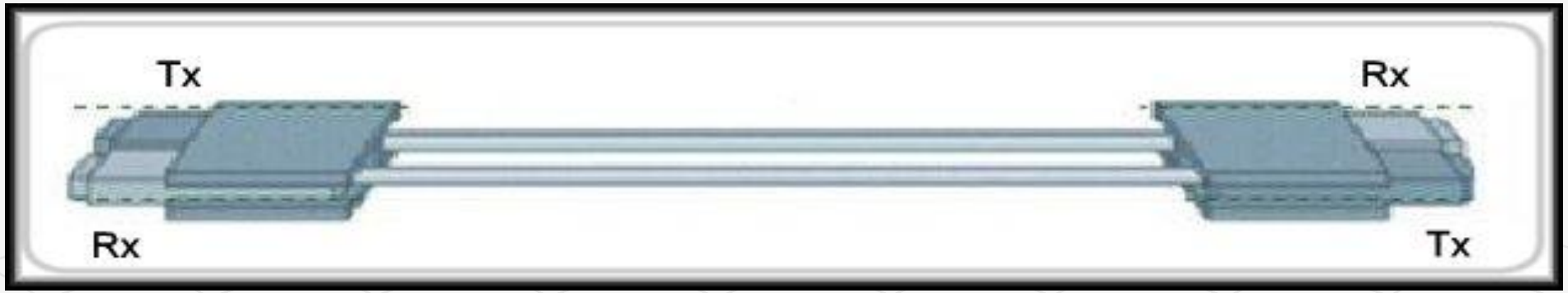




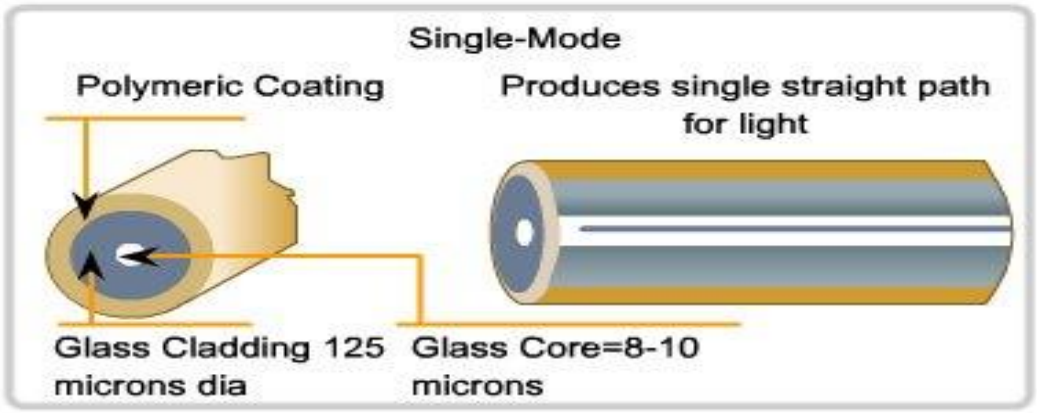
Fiber Media

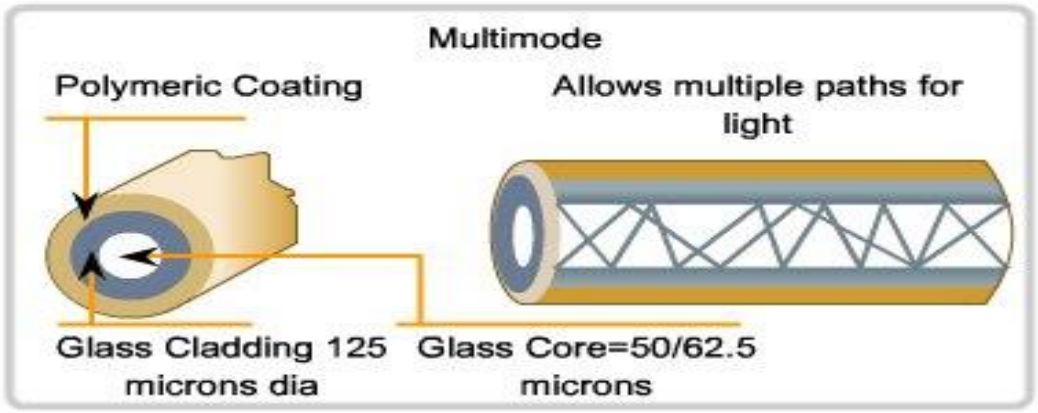
Cable Construction:

- PVC jacket and a series of strengthening materials that surround the optical fiber and its cladding.
- The cladding surrounds the actual glass or plastic fiber and is designed to prevent light loss from the fiber.
- Two fibers are required to support full duplex operation.



Fiber Media





- Small Core
- Less Despersion
- Suited for long distance applications (up to 100 km, 62,14 mi.)
- Uses lasers as the light source often within campus backbones for distance of several thousand meters

- Larger core than single-mode cable (50 microns or greater)
- Allows greater dipersion and therefore, loss of signal
- Used for long distance appllication, but shorter than single-mode (up to ~2km, 6560 ft)
- Uses LEDs as the light source often within LANs or distances of a couple hundred meters within a campus network

Fiber Media Connectors

ST Connector

Straight Tip (ST) connector is widely used with multimode fiber

SC Connector

Subscriber Connector (SC) is widely used with single-mode fiber

Single-Mode (LC)

Single-Mode Lucent Connector (LC)

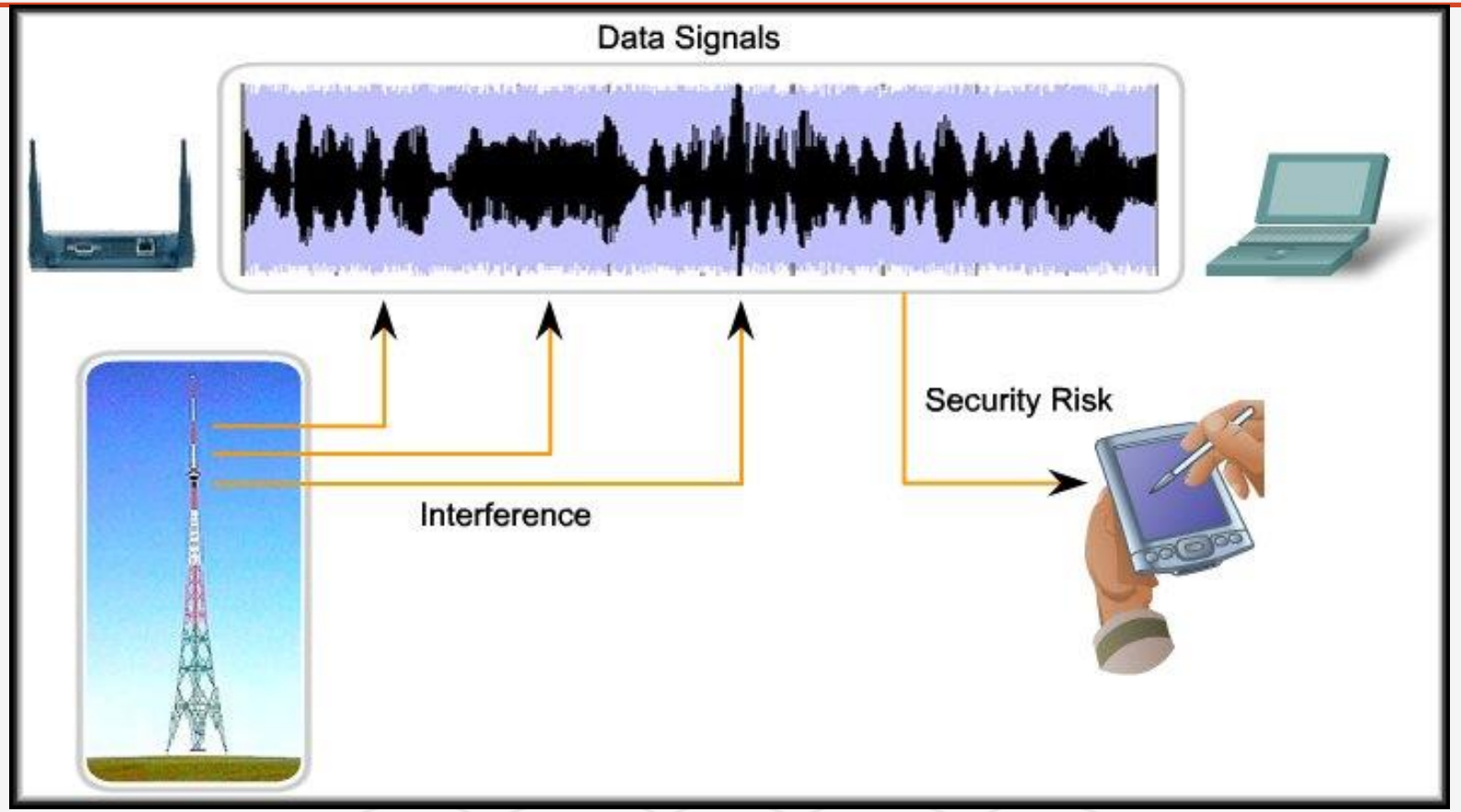
Multimode (LC)

Multimode LC Connector

Duplex Multimode (LC)

Duplex Multimode LC Connector

Wireless Media



Wireless media carry electromagnetic signals at radio and microwave frequencies that represent the binary digits of data communications.

Wireless Media

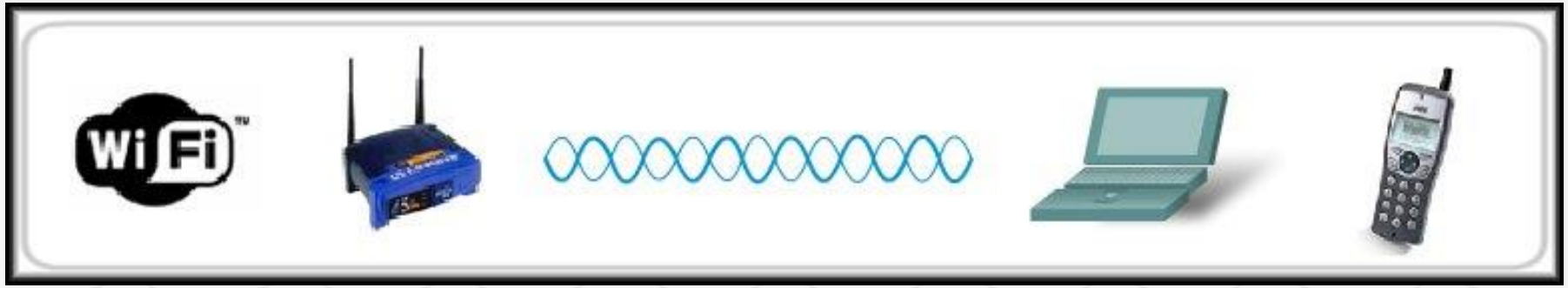
Types of Wireless Networks:

- Standards cover both the Data Link and Physical layers.
  - Four common data communications standards:
    - Standard IEEE 802.11: Wireless LAN (WLAN) standard.
    - Standard IEEE 802.15: Wireless Personal Area Network (WPAN) standard.
    - Standard IEEE 802.16: Wireless broadband access.
    - Global System for Mobile Communications (GSM): Data transfer over mobile cellular telephony networks.

Wireless Media

Standard IEEE 802.11:

- Wireless LAN (WLAN) standard.
- Commonly referred to as Wi-Fi.
- Uses a contention system with Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA).



Wireless Media

Standard IEEE 802.11:

- Wireless LAN (WLAN) standard.

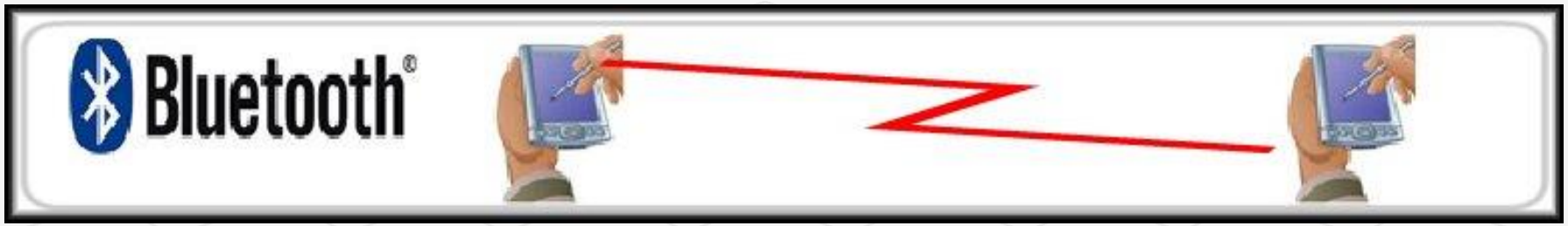
Wireless Media

IEEE Standard	Description/ Characteristics
802.11a	• Operates in the 5-Ghz frequency band • Speeds up to 54 Mbps • Small coverage area • Not interoperable with 802.11b or 802.11g
802.11b	• Operates in the 2.4 GHz frequency band • Speeds up to 11 Mbps • Longer range • Better able to penetrate building structures
802.11g	• Operates in the 2.4 GHz frequency band • Speeds up to 54 Mbps • Bandwidth of 802.11a with 802.11b range
802.11n	• Currently in draft form • Propose 2.4 GHz or 5 GHz • Expected data rates are 100 Mbps to 210 Mbps

Wireless Media

Standard IEEE 802.15:

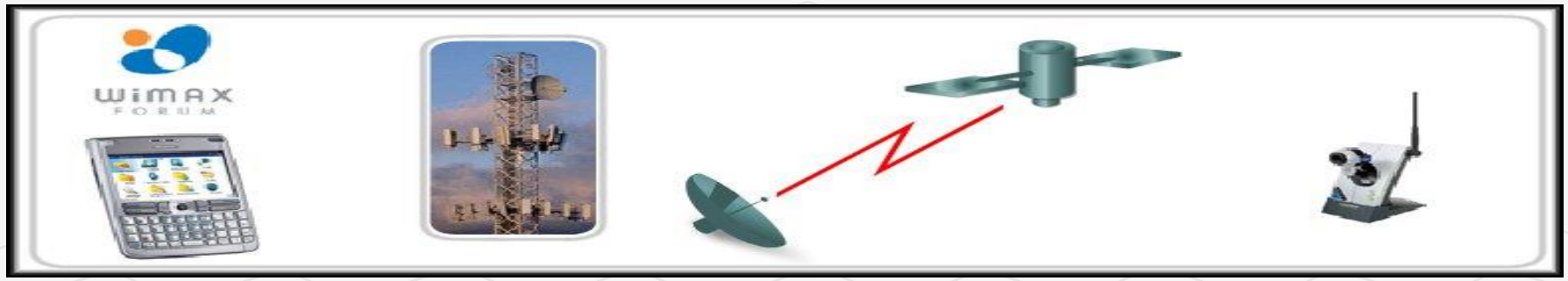
- Wireless Personal Area Network (WPAN) standard.
- Commonly known as "Bluetooth“
- Uses a device pairing process to communicate over distances from 1 to 100 meters.



Wireless Media

Standard IEEE 802.16:

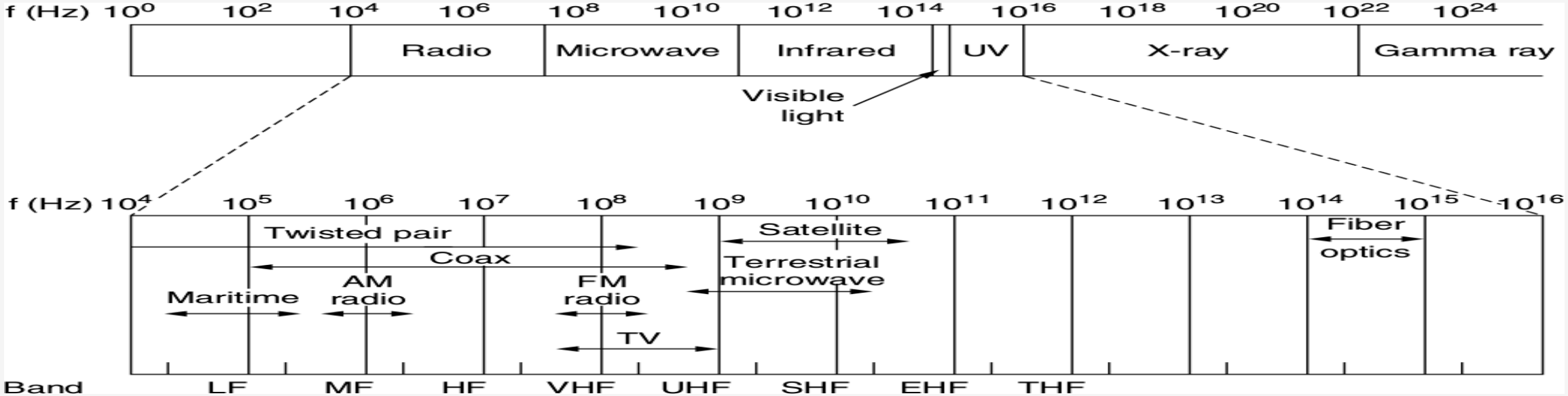
- Wireless broadband access.
- Commonly known as WiMAX (Worldwide Interoperability for Microwave Access)
- Uses a point-to-multipoint topology to provide wireless broadband access.



Wireless Media

The electromagnetic spectrum

- **Frequency** – The number of oscillations per second of a wave. Frequency is measured in Hz.
- **Wavelength** – the distance between two consecutive maxima (or minima).

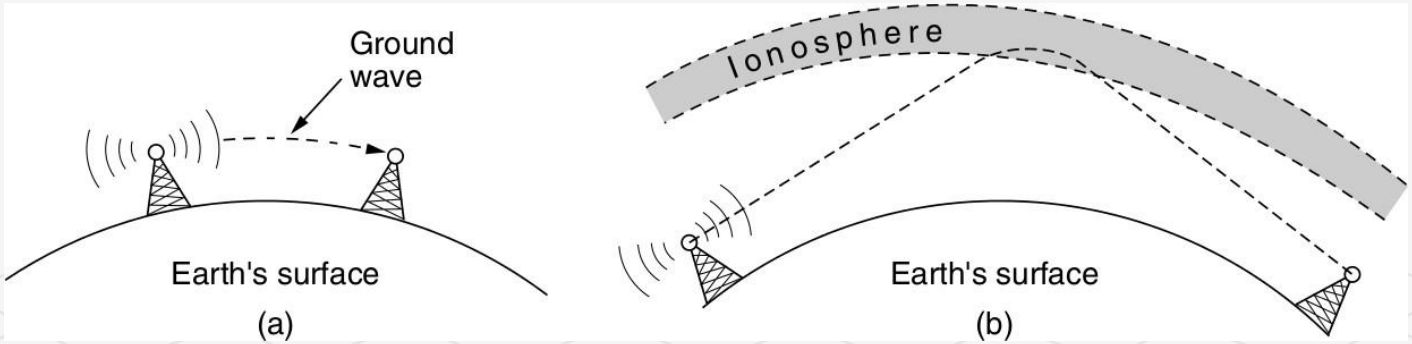


Wireless Media

- Unguided media
- Transmission and reception via antenna
- Directional
  - ✓ Focused beam
  - ✓ Careful alignment required
- Omni-directional
  - ✓ Signal spreads in all directions
  - ✓ Can be received by many antennae

Wireless Media

- Radio transmission
- Radio waves are easy to generate, can travel long distances, and penetrate buildings easily.
- Radio waves of VLF, LF and MF bands follow the ground - eg. AM Radio.
- In HF and VHF bands, the ground waves tend to be absorbed by the earth. However, they bounce off from the ionosphere - eg. FM Radio, TV



Lecture -3: Network Devices

End of the Lecture – 2

Thank You