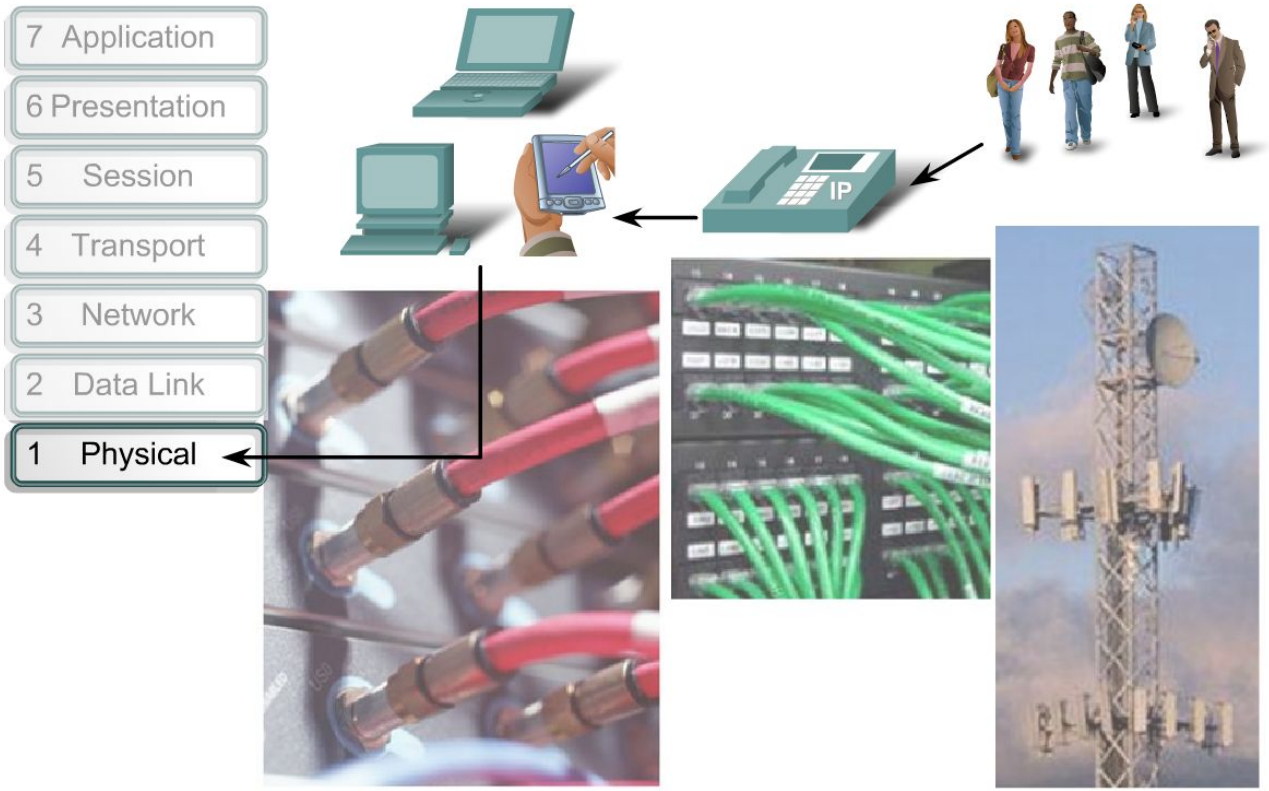
Data and Computer Communications

Chapter 7
Physical Layer
Transmission Media

Physical Layer

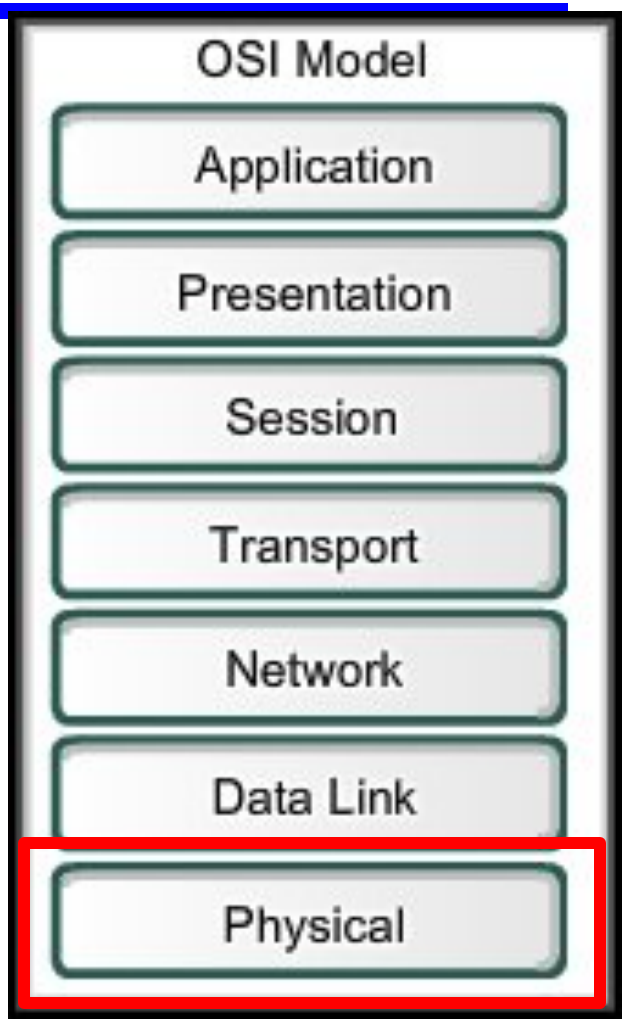
- Provides the means to transport across the network media the bits that make up a Data Link layer frame.



The Physical layer interconnects our data networks.

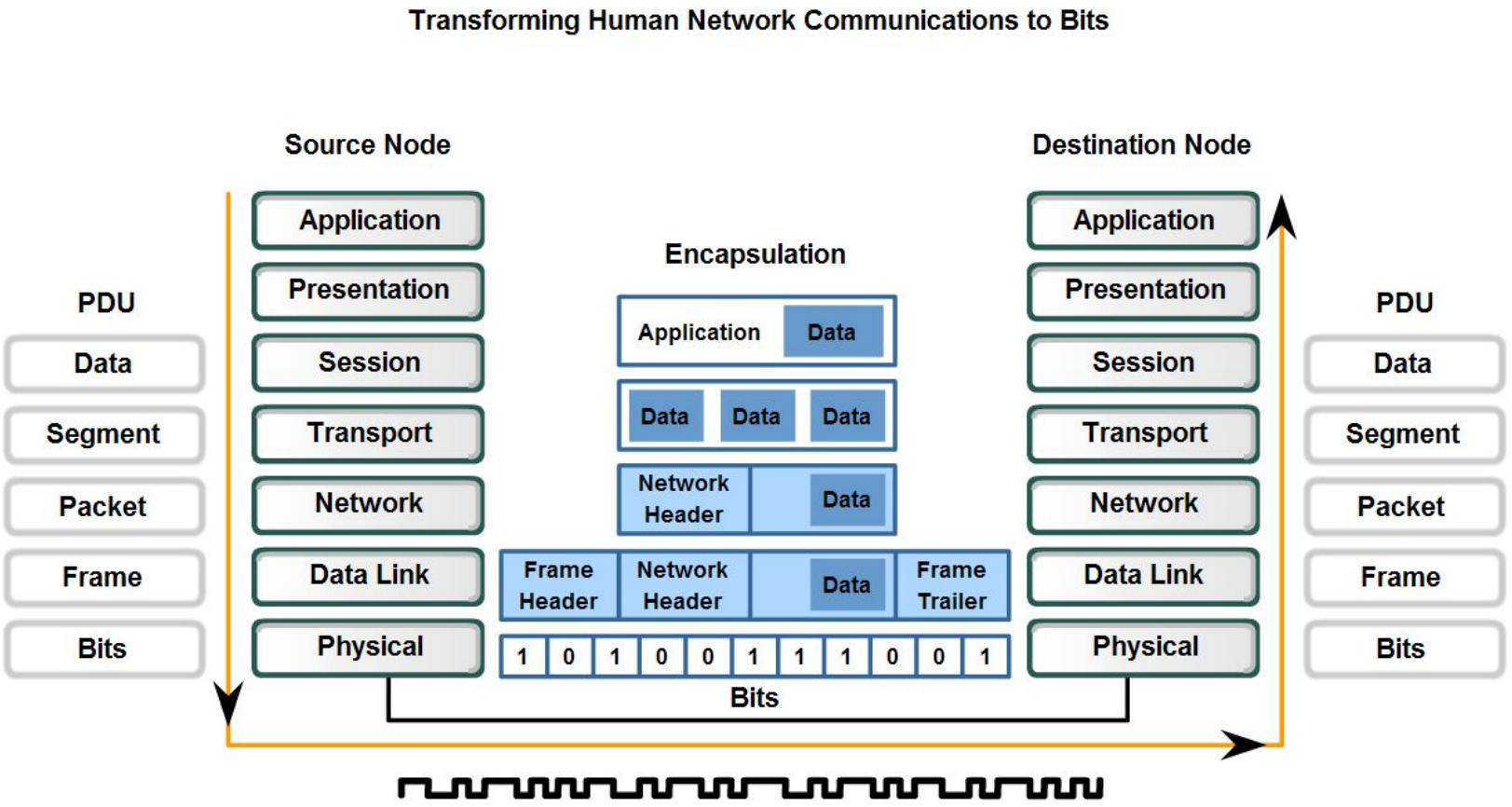
Physical Layer Elements

- 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.



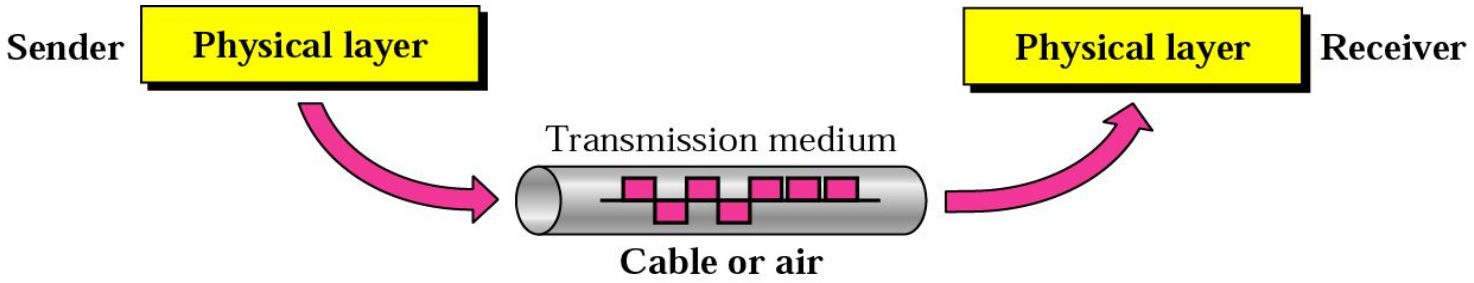
Physical Layer

The purpose of the Physical layer is to create the electrical, optical, or microwave signal that represents the bits in each frame.

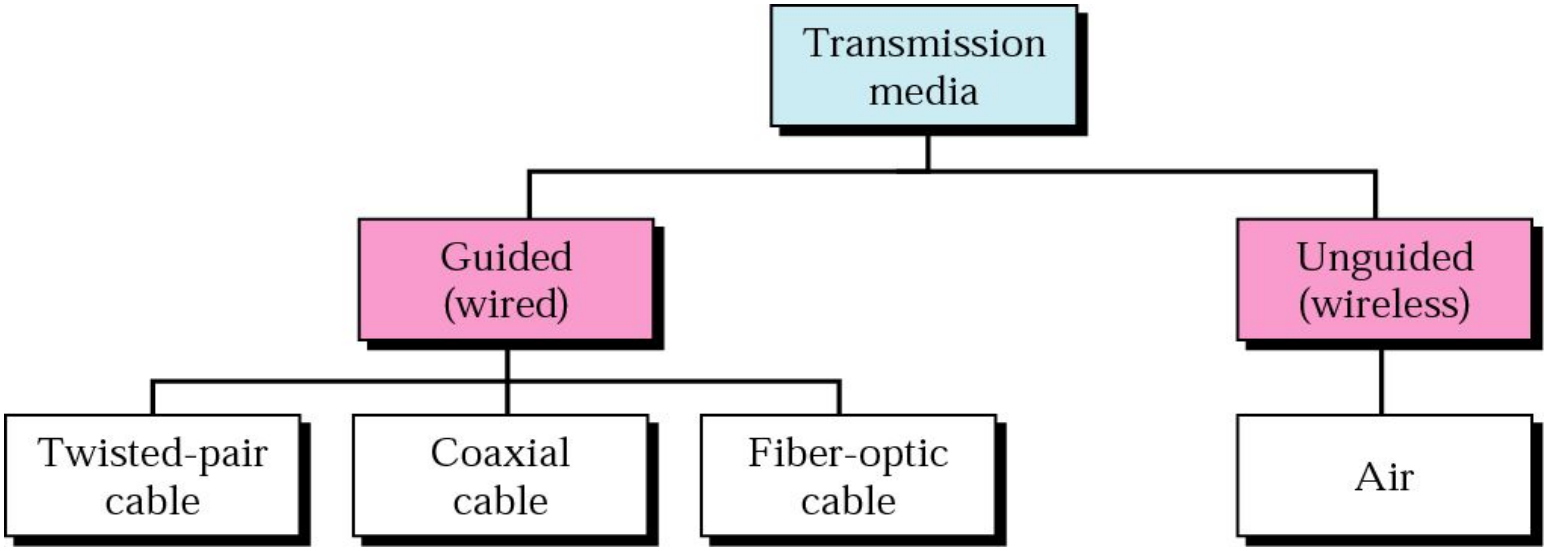


Transmission Media

- Transmission media are located below the physical layer and directly controlled by the physical layer.



Transmission Media-Types



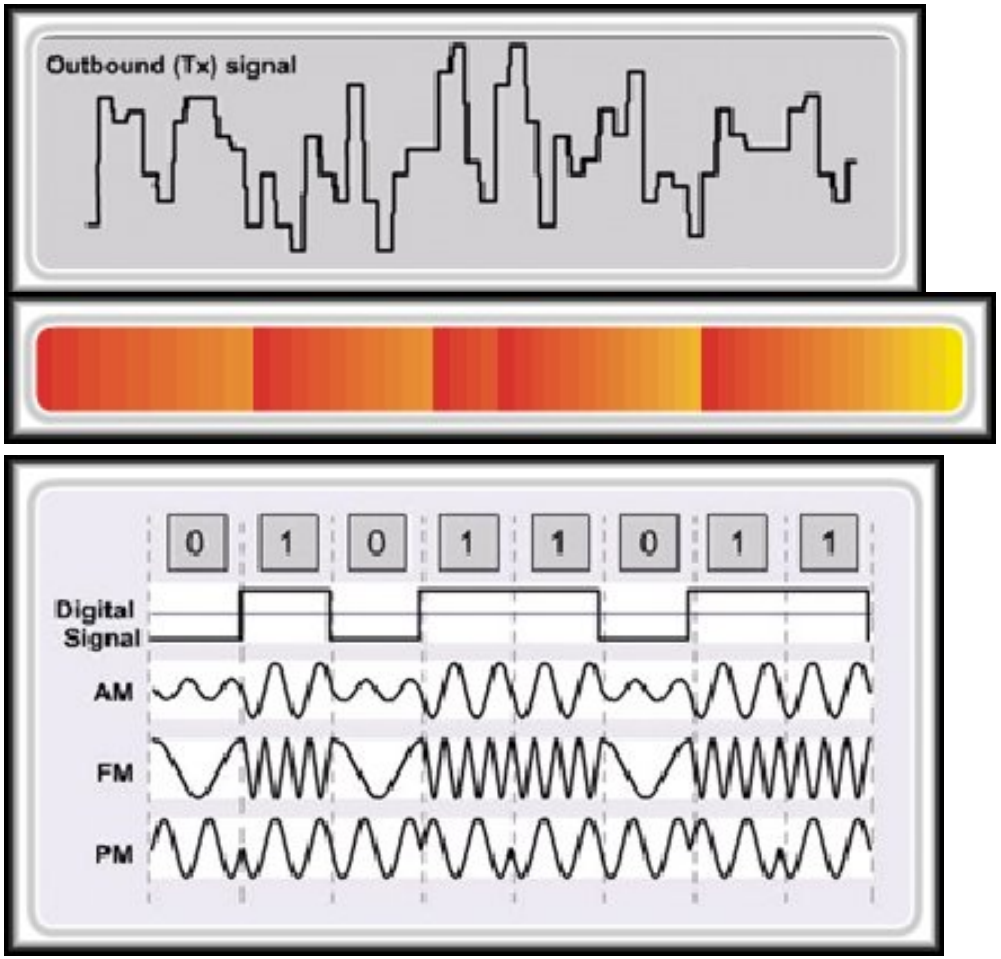
Physical Layer Operation

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

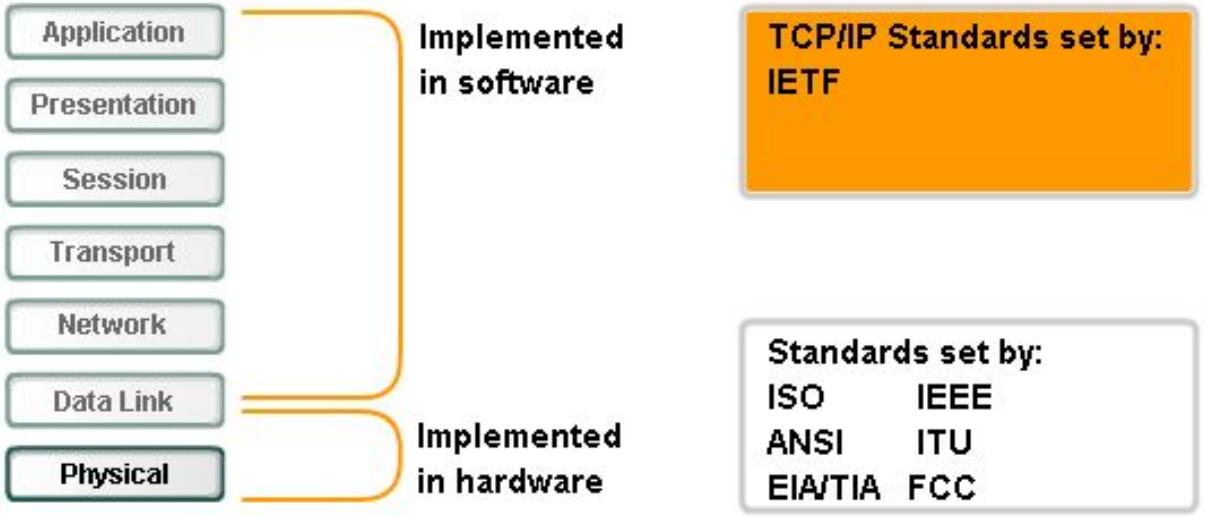
Copper Cable

Fiber-optic

Wireless



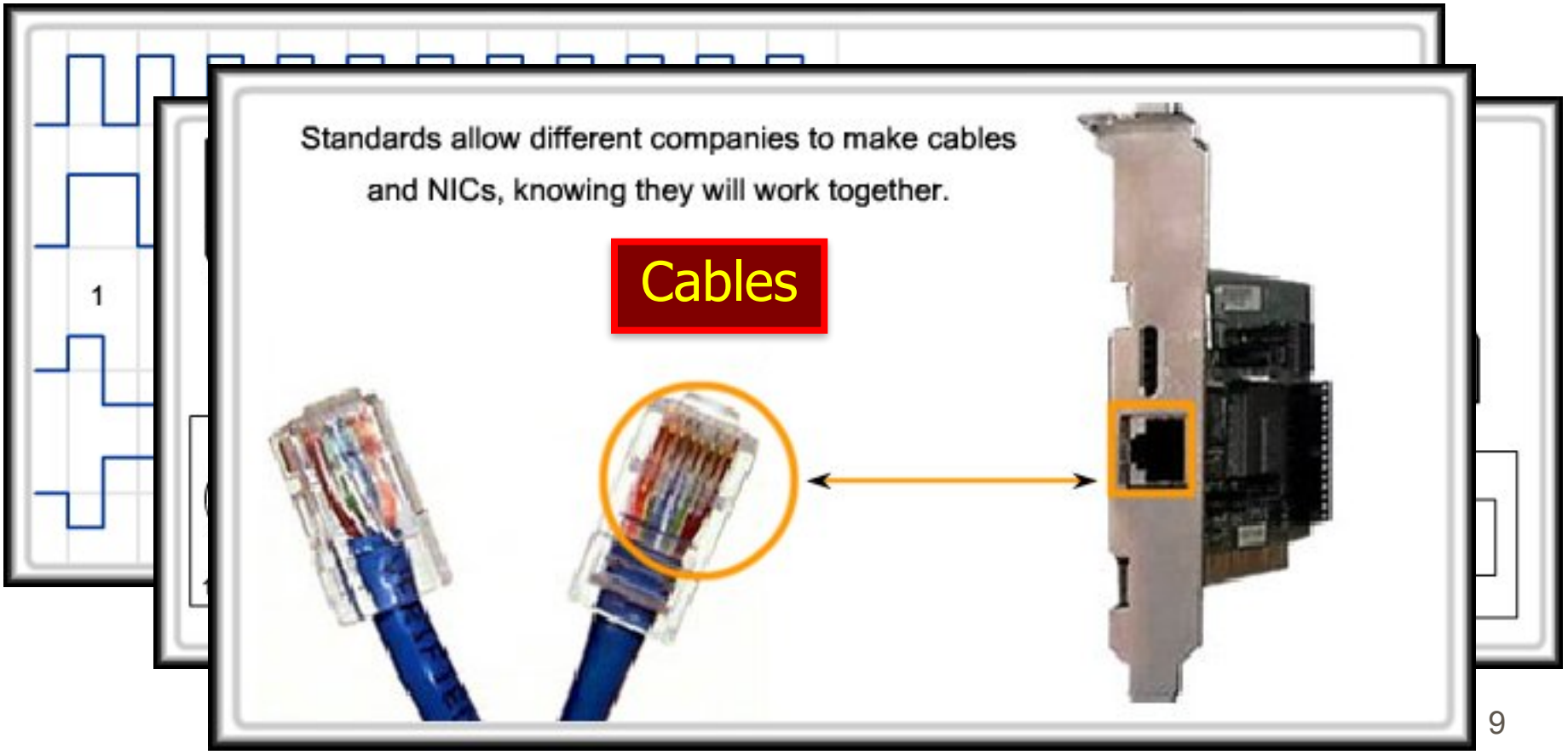
Standards



- Physical layer standards:
  - Physical and electrical properties of the media
  - Mechanical properties (materials, dimensions, pinouts) of the connectors
  - Bit representation by the signals (encoding)

Physical Layer Standards

- The technologies defined by these organizations include three basic areas of the Physical layer standards:



Overview

- Guided (wire) and unguided (wireless) use electromagnetic waves.
- Characteristics and quality of a data transmission determined by medium and signal.
- For guided
  - the medium is more important.
- For unguided
  - the bandwidth produced by the antenna is more important.

Design Factors

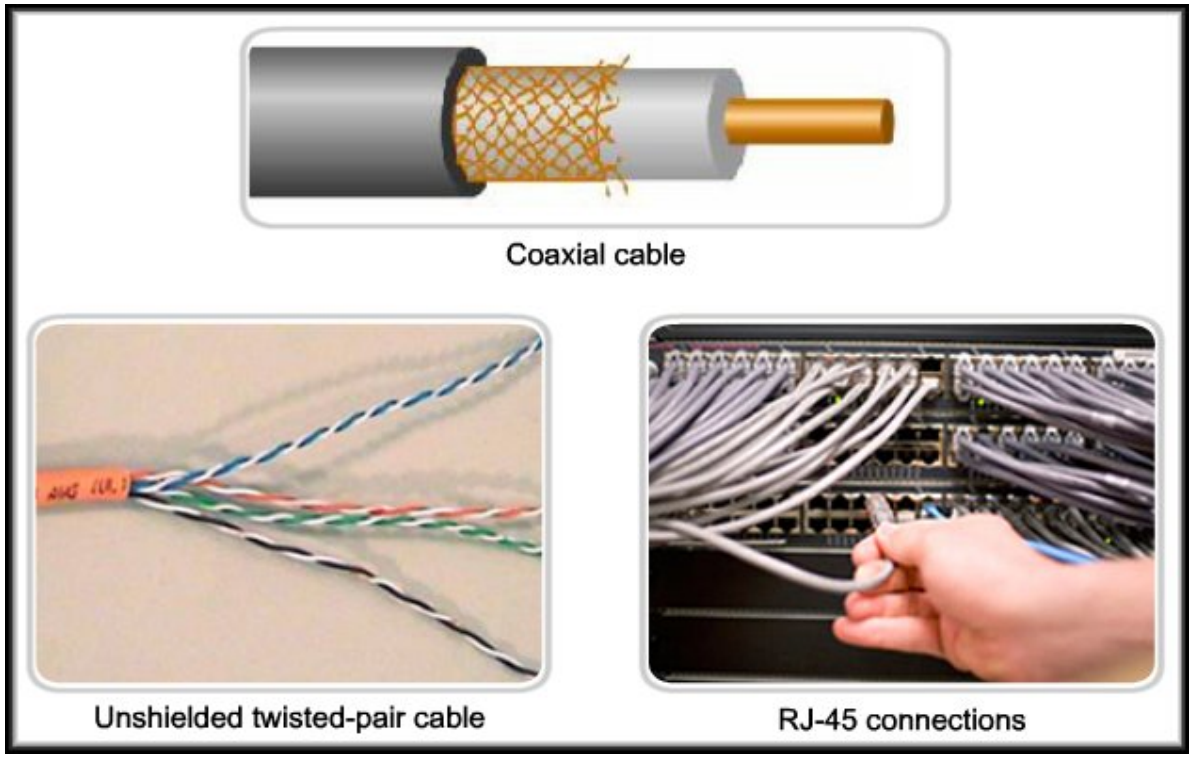
- Key concerns are data rate and distance. These depend on:
- Bandwidth
  - Higher bandwidth gives higher data rate
- Transmission impairments
  - Attenuation
- Interference
- Number of receivers
  - In guided media
  - More receivers (multi-point) introduce more attenuation

Transmission Media

- Guided media
  - Twisted-pair
  - Coaxial Cable
  - Optical Fiber
- Unguided media
  - Satellites
  - Terrestrial Microwave
  - Broadcast Radio

Copper Media

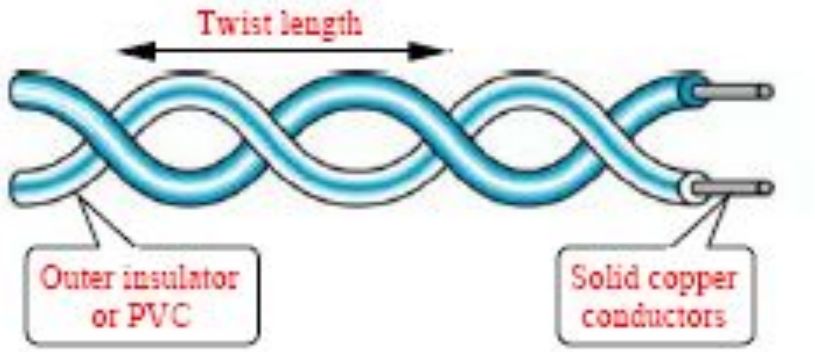
- Most common means for connecting network devices.
- Standards been defined for:



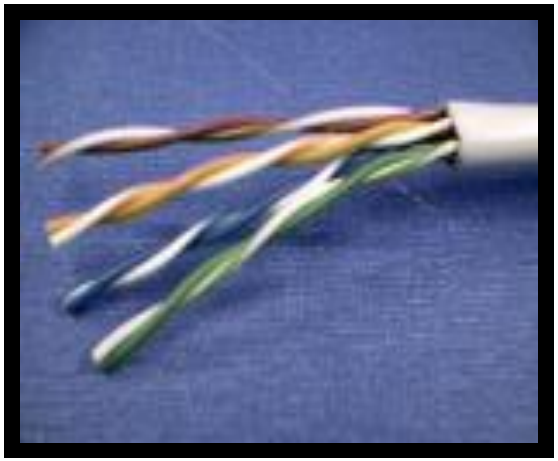
- Type of copper cabling
- Bandwidth
- Type of connector
- Colour codes of media connections
- Maximum distance

Twisted Pair

- Most common medium
- Two separately insulated copper wires twisted together.

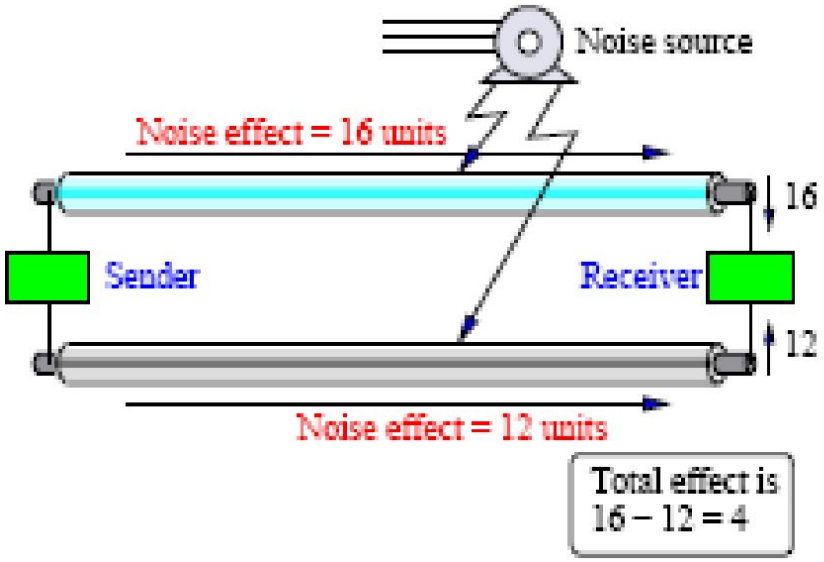


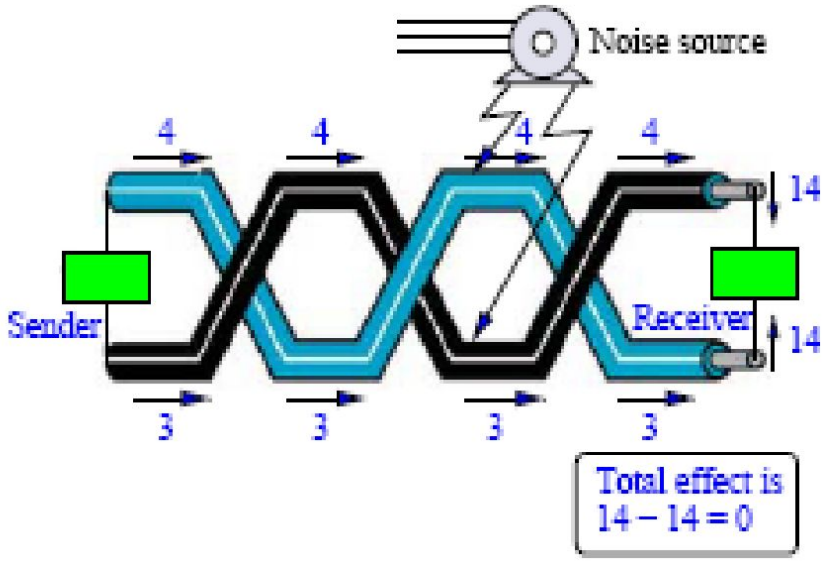
- Often "bundled" into cables.



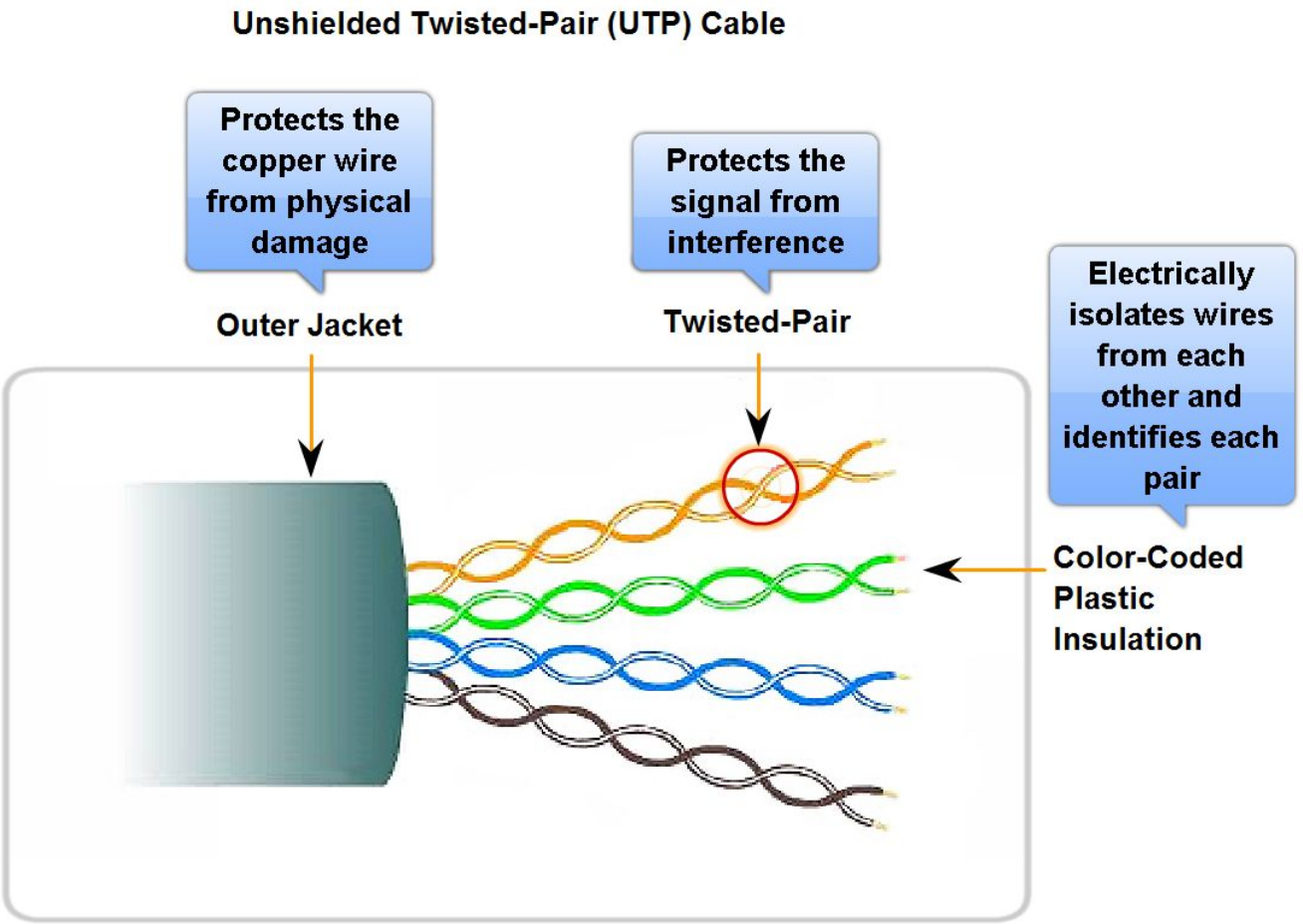
Effect of Noise on Parallel and Twisted-Pair Lines

- Twisting allows each wire to have approximately the same noise level and reduces crosstalk.





Twisted Pair

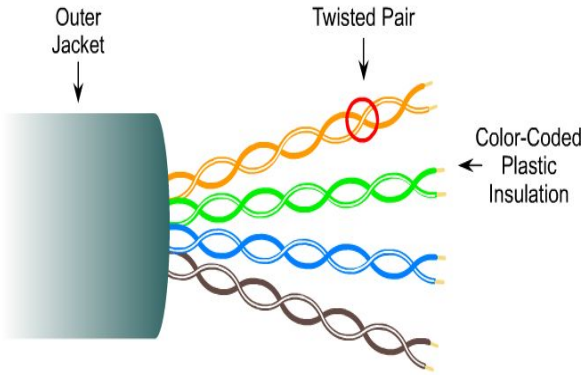


Twisted Pair

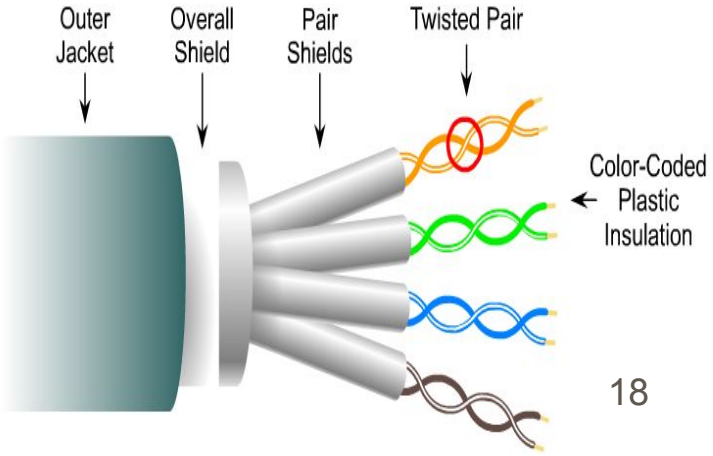
- Applications:
  - Most common medium
  - Telephone network
    - Between house and local exchange (subscriber loop)
  - Within buildings
    - To private branch exchange (PBX)
  - For local area networks (LAN)
    - 10Mbps or 100Mbps
- Pros
  - Cheap and easy to work with
- Cons
  - Low data rate and short range

Unshielded and Shielded TP

- Unshielded Twisted Pair (UTP)
  - Ordinary telephone wire
  - Cheapest
  - Easiest to install
  - Suffers from external EM interference



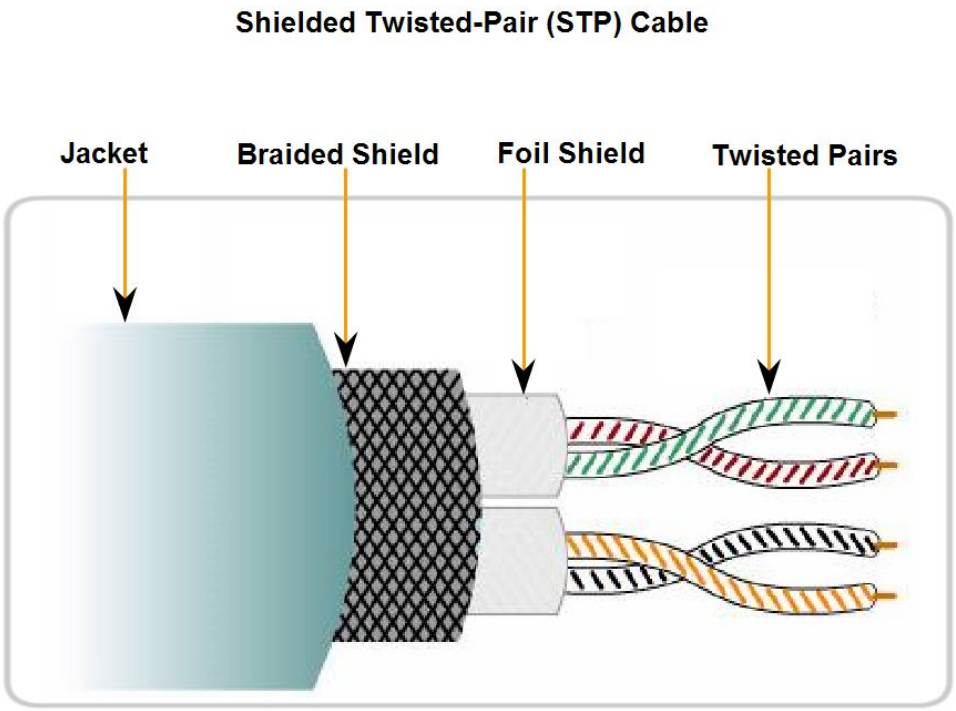
- Shielded Twisted Pair (STP)
  - Metal braid or sheathing that reduces interference
  - More expensive
  - Harder to handle (thick, heavy)



UTP Standards

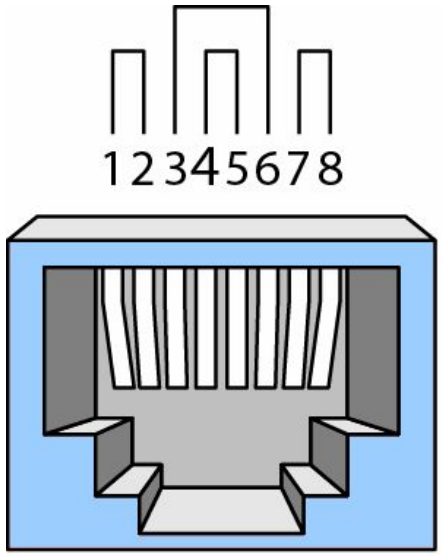
- Unshielded Twisted-Pair (UTP) Cable:
  - TIA/EIA standards include:
    - Cable types
    - Cable lengths
    - Connectors
    - Cable Termination
    - Methods of testing
  - IEEE assigns categories based on bandwidth performance.
    - Cat 5 – up to 100-megabit
    - Cat 5e – full-duplex up to 1000-megabit (gigabit)
    - Cat 6 – recommended standard for gigabit

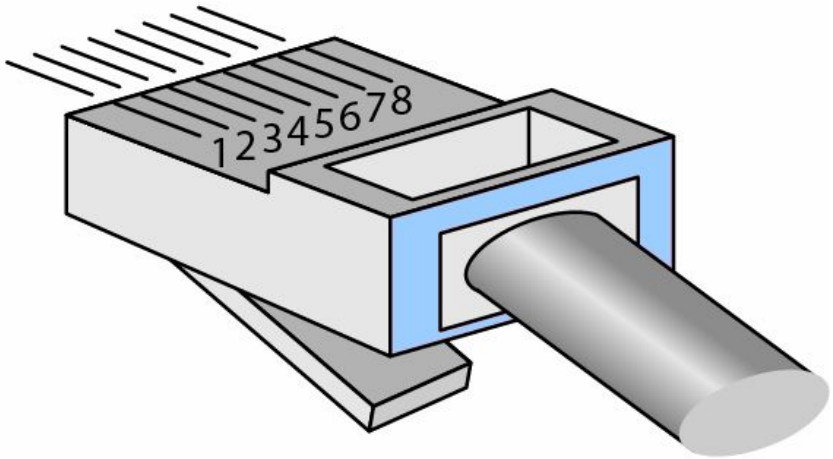
STP

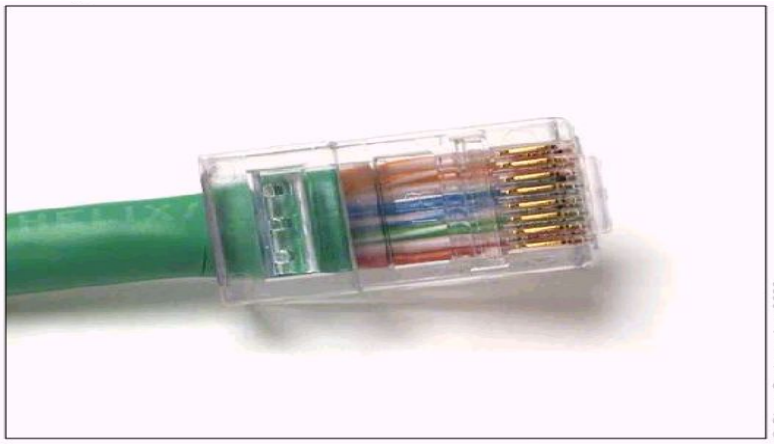


- STP mostly used in Token Ring.
- Now the new 10 GB standard for Ethernet has a provision for the use of STP cabling.

UTP Connectors-RJ-45



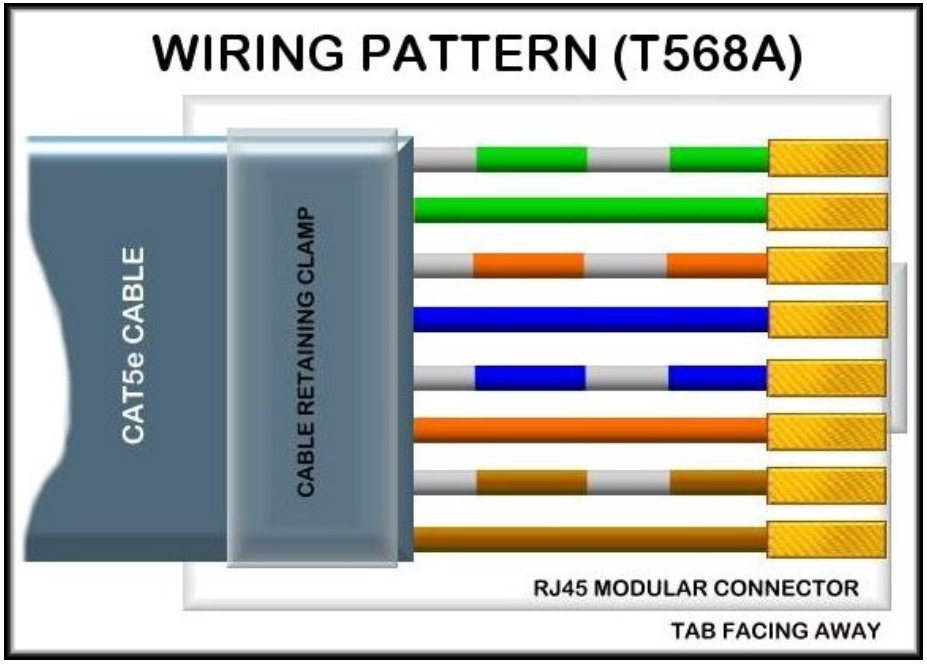


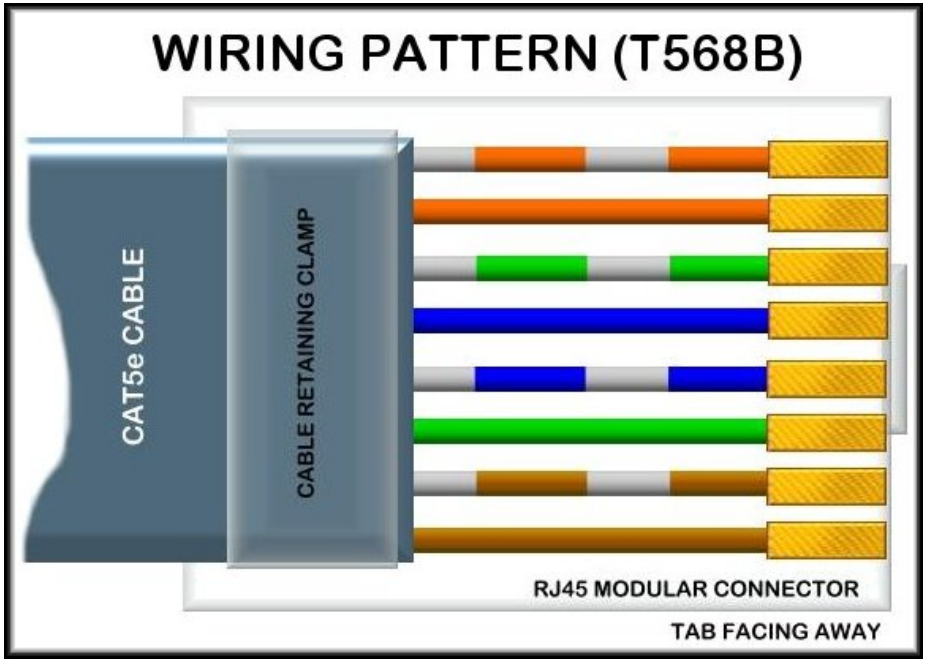



Good Jacket Length
Properly Crimped

UTP Cable

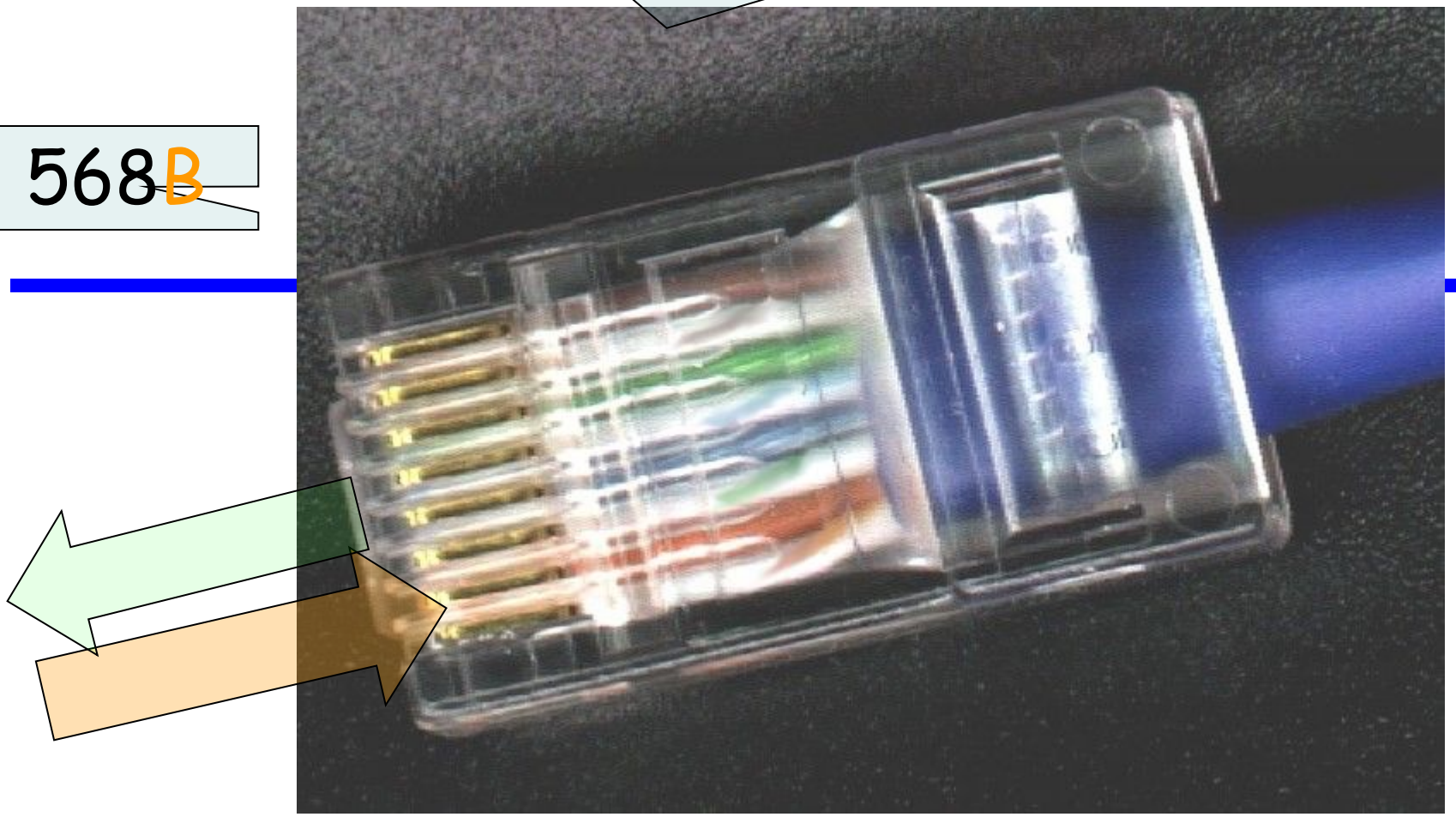
- Wiring Patterns:
  - There are two specific TIA/EIA standard wiring patterns:





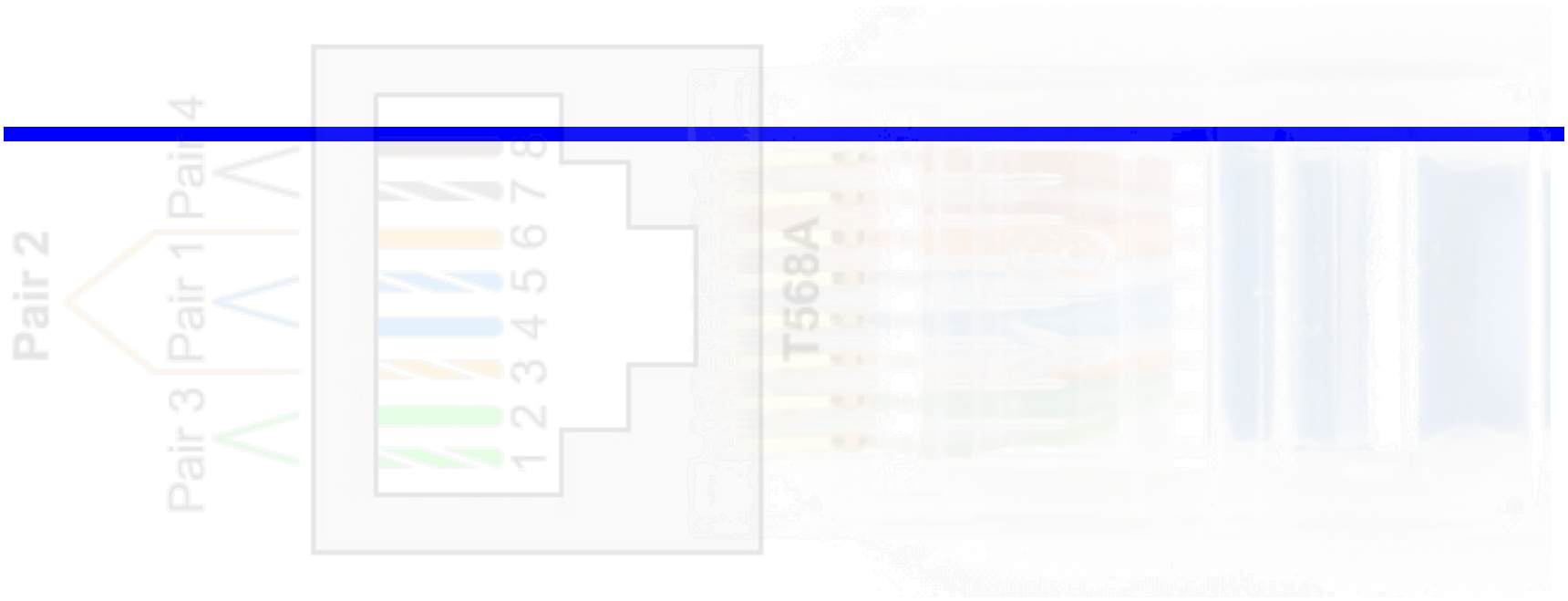
Signal leaves the cable and enters the NIC on the **SPLIT** Green pair. White-Green is +ve, solid Green is negative.

568B



Signal leaves the NIC and enters the cable on the Orange pair. White-Orange is +ve, solid Orange is negative.

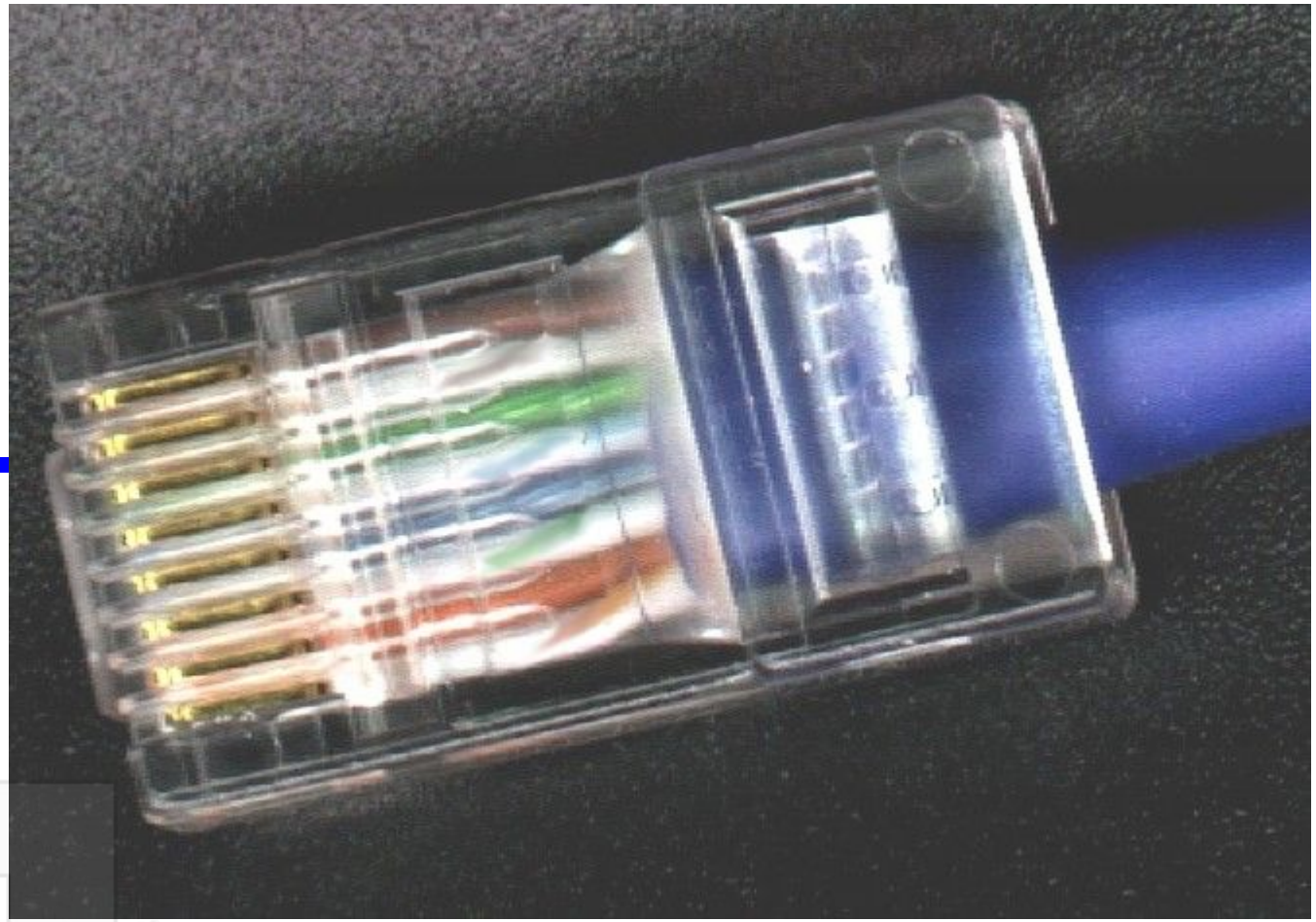
This is the Jack

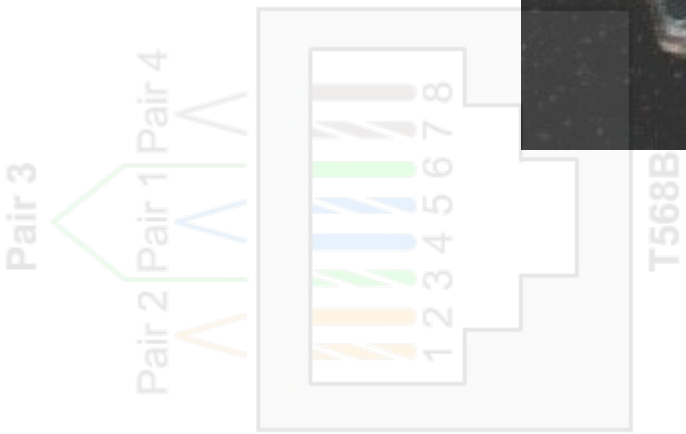


568A

This is the Connector

This is the Jack





568B

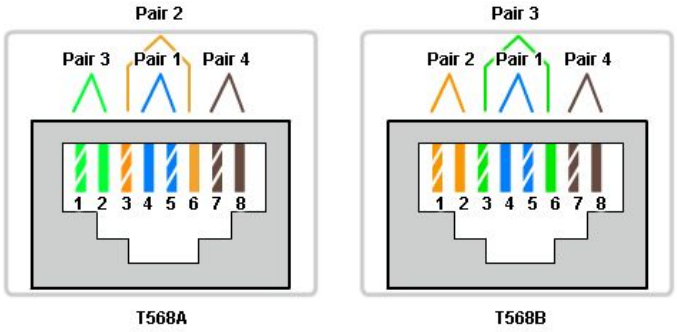
This is the Connector

UTP Cable Types

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

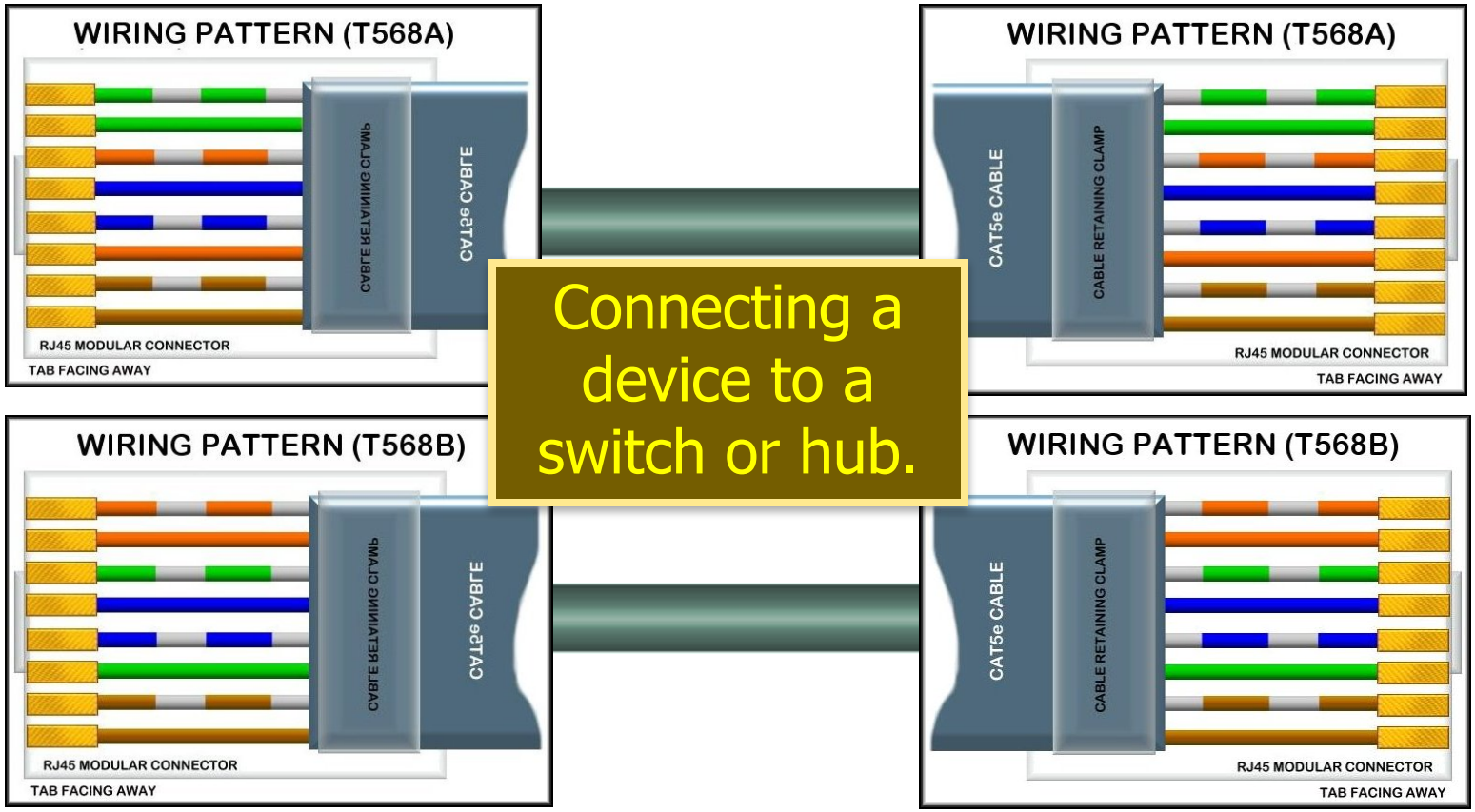
Straight-through, Crossover, and Rollover Cable Types

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



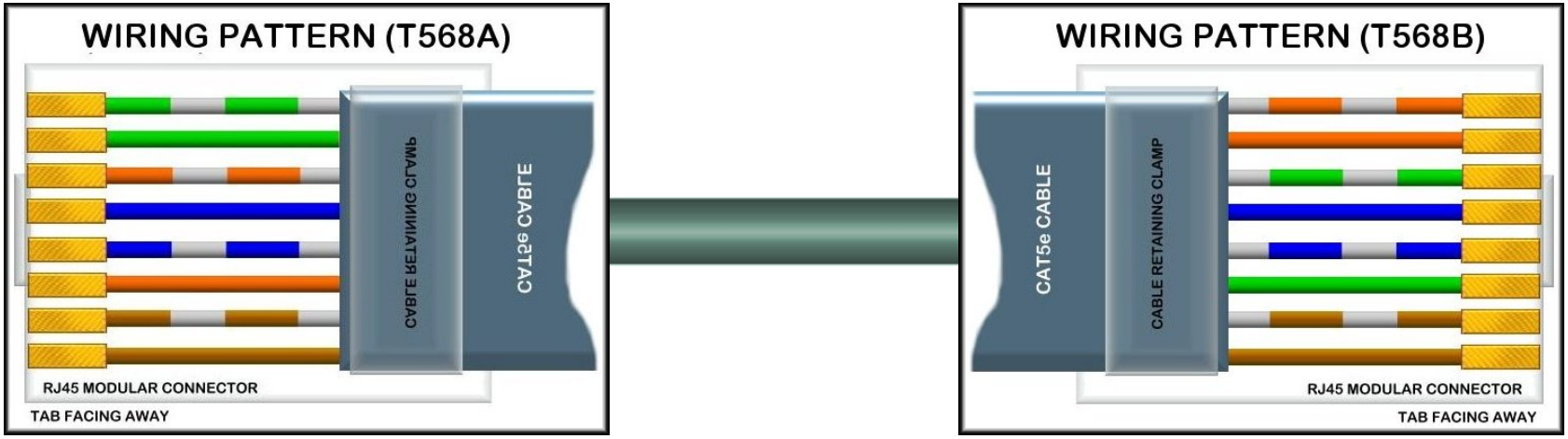
UTP Cable Types

- Ethernet Straight-through:
  - T568A or T568B may be used as long as the same pattern is used at both ends of the cable.



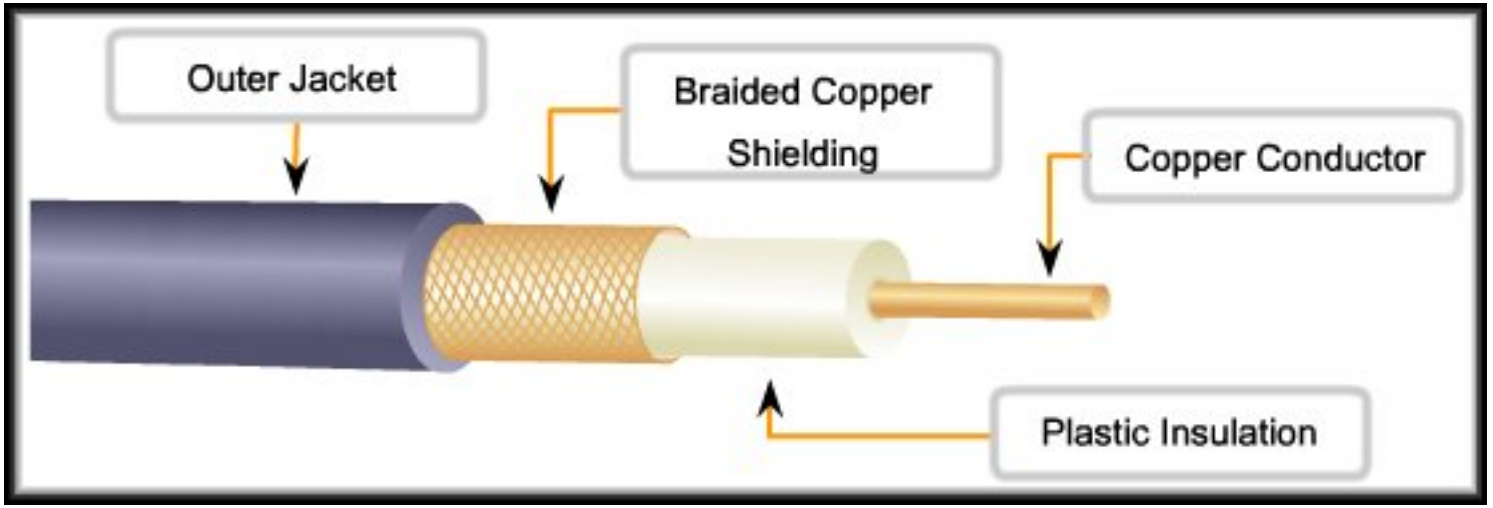
UTP Cable Types

- 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



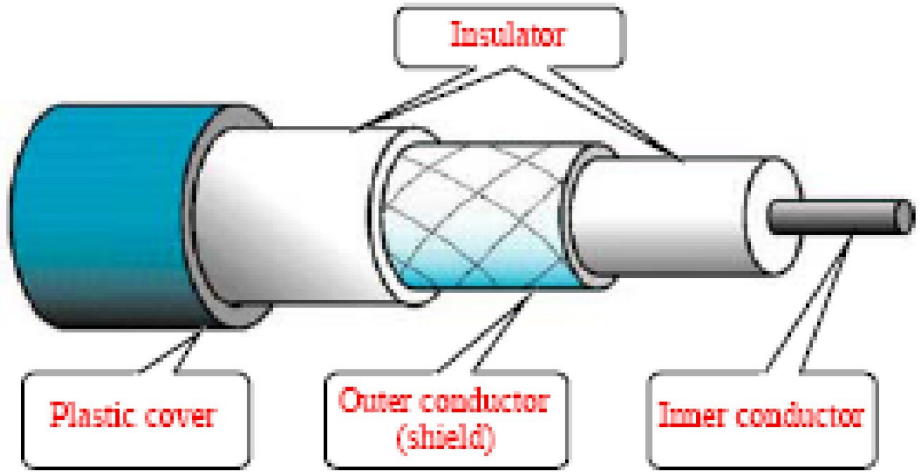
Copper Media-Coaxial Cables

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

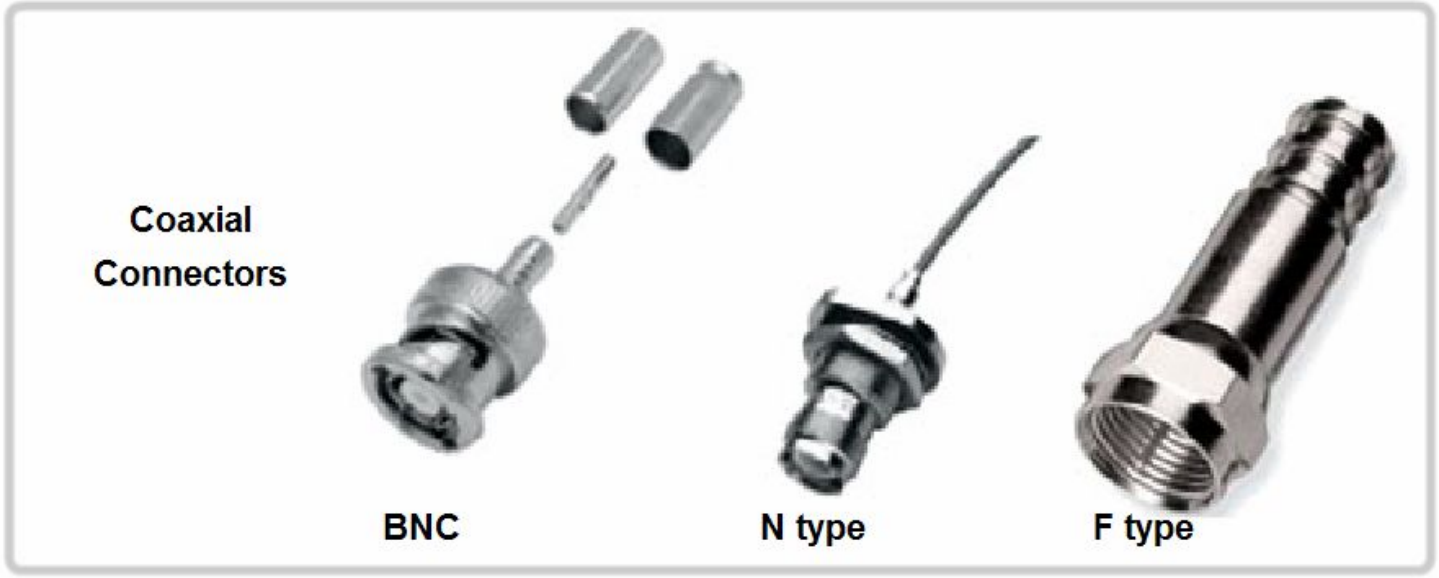


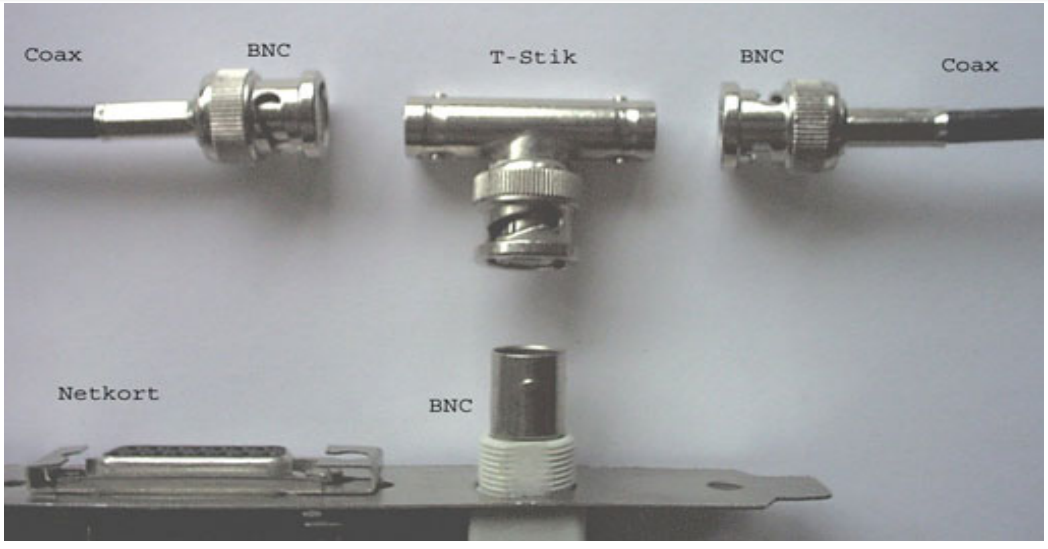
Coaxial Cable

- **Physical description:**
- Central conductor - usually copper.
- Inner conductor wire surrounded by insulation
- A metallic outer conductor (shield), serves as a ground.
- An insulator covering the centre conductor.
- A plastic jacket .



Coaxial Cable and Connectors





Coaxial Cable Applications

- Most versatile medium
- Traditional cable television, exclusively transmitting in one direction, was composed completely of coax cable.
- Long distance telephone transmission
  - Can carry 10,000 voice calls simultaneously
  - Being replaced by fiber optics, microwave & satellite
- Attaches antennas to wireless devices. The coaxial cable carries radio frequency (RF) energy between the antennas and the radio equipment.
- Local area networks, but now replaced by UTP.

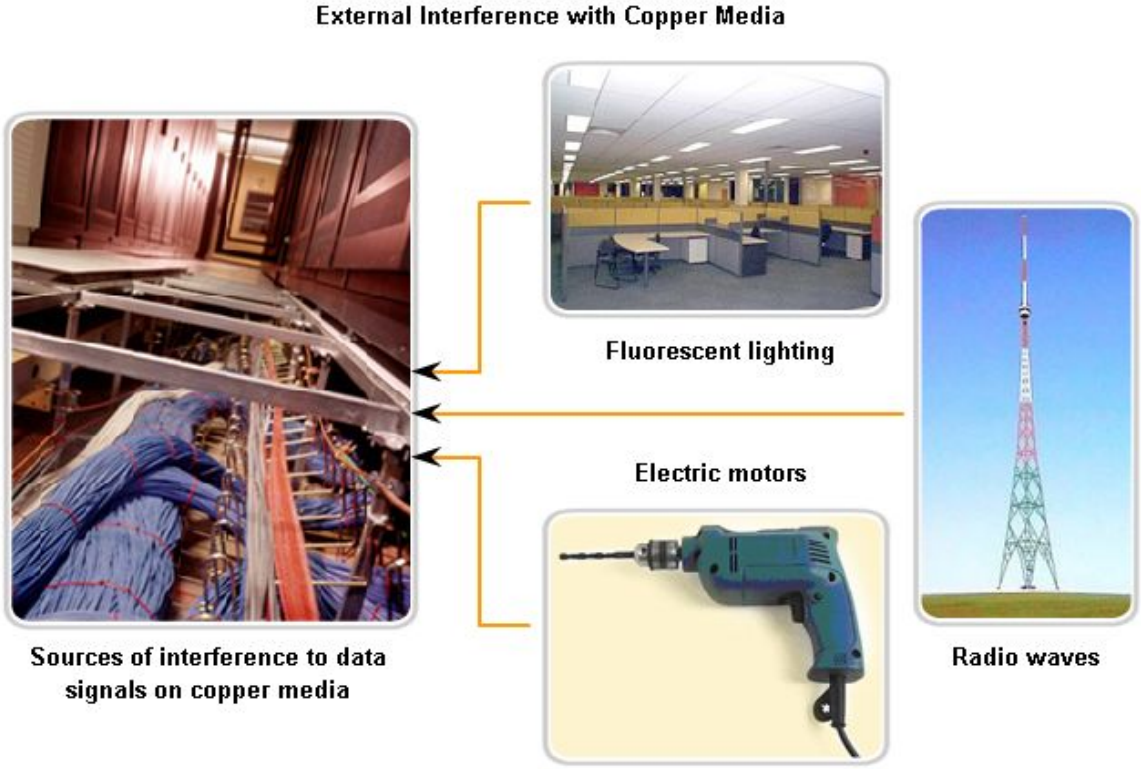
Coaxial Cable

- **Advantages**:
  - Requires fewer repeaters than twisted pair
  - Less expensive than fiber
  - It has been used for many years for many types of data communication, including cable television
- **Disadvantages**:
  - More expensive and more difficult to install than twisted pair
  - Needs more room in wiring ducts than twisted pair

Categories of Coaxial Cables

Category	Impedance	Use
RG-59	75 ohm	Cable TV
RG-58	50 ohm	Thin Ethernet
RG-11	50 ohm	Thick Ethernet

Interference in Copper Media

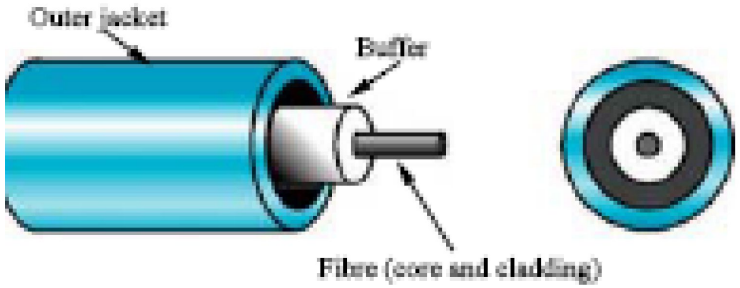


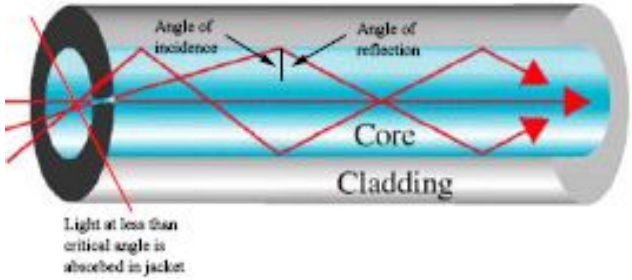
- Unwanted signals can distort and corrupt the data signals being carried by copper media.
- Radio waves and electromagnetic devices such as fluorescent lights, electric motors, and other devices are potential sources of noise.

Solutions

- Selecting the cable type or category most suited to protect the data signals in a given networking environment
- Designing a cable infrastructure to avoid known and potential sources of interference in the building structure
- Using cabling techniques that include the proper handling and termination of the cables

Fiber Optic Cable

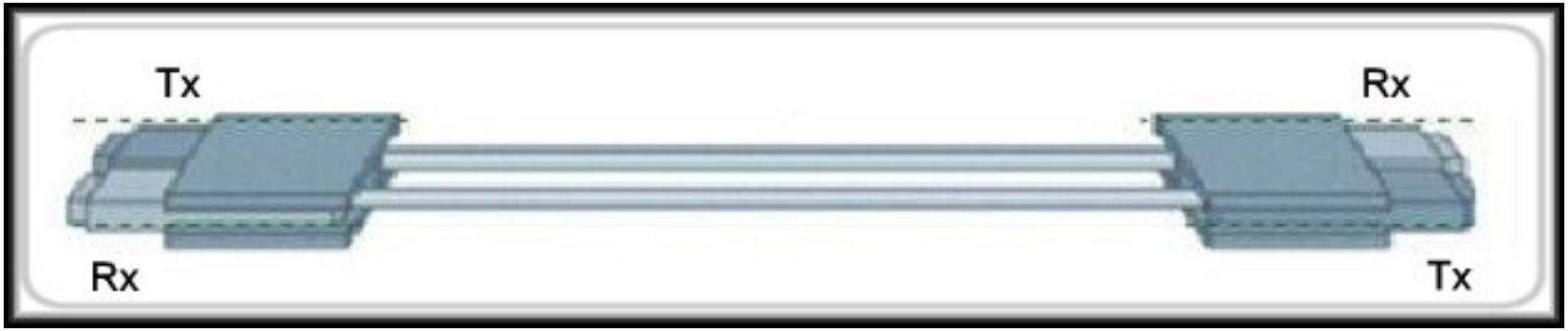




- Physical description:
  - **Optical Signal** is carried by photon pulses through thin (8 to 10 microns) **glass** strands (optical fibers)
  - light waves are produced either by **Light emitting diodes** (LEDs) or injection **laser diode** (ILD).
  - at transmitting and receiving end, signal is converted from and reconverted to electrical form by optical modems such as an avalanche **photo diode**.

Fiber Optic Cable

- 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.



Challenges

- 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