Physical Layer

📕 CCNA1v7 Module 4 Physical Layer

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The Physical Layer

Physical Layer Standards address 3 functional areas:

- 💪🏻 **Physical Components:** NICs (Network Interface Card), interfaces and connectors, cable materials, and cable designs
- 🤖 **Encoding:** converts the stream of bits into a format recognizable by the next device in the network path.
- 🚦 **Signaling:** how the bit values, “1” and “0” are represented on the physical medium. The method of signaling will vary based on the type of medium being used.

Bandwidth

- **Bandwidth:** capacity at which a medium can carry data. Bits per second (bps), Mbps (Megabits per second), Gbps (Gigabits per second). 1Gbps = 10^6 bps
- **Terminology**
  - ⏳ **Latency:** Amount of time, including delays, for data to travel from one given point to another
  - 🌪️ **Throughput:** The measure of the transfer of bits across the media over a given period of time
  - 🌊 **Goodput:** The measure of usable data transferred over a given period of time

🧮 **Goodput = Throughput - traffic overhead**

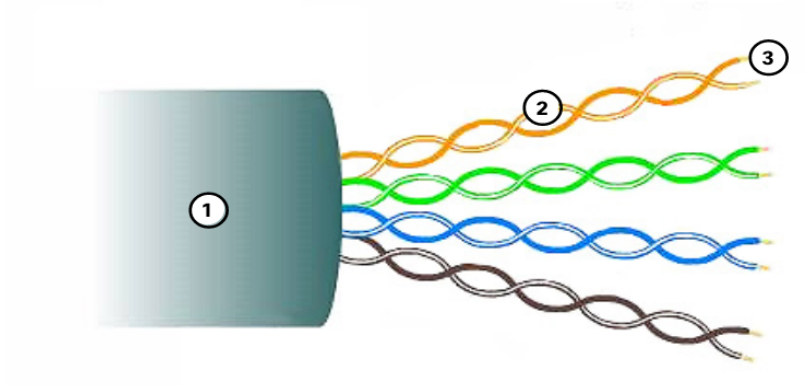
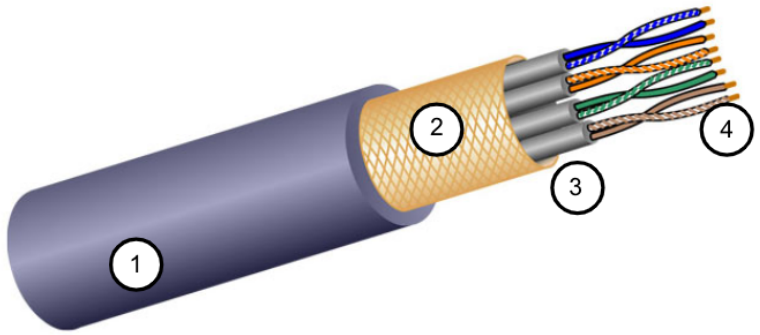
Copper cabling

🟢 Most common type of cabling used today, inexpensive, easy to install, and has low resistance to electrical current flow.

🟡 **Limitations:**

- **Attenuation:** the longer the electrical signals have to travel, the weaker they get.
  - 🟦 Mitigation: Strict adherence to cable length limits
- **Interferences:**
  - Electromagnetic Interference (EMI) and Radio Frequency Interference (RFI)
    - 🟦 Mitigation: metallic shielding and grounding
  - Crosstalk
    - 🟦 Mitigation: twisting opposing circuit pair wires together

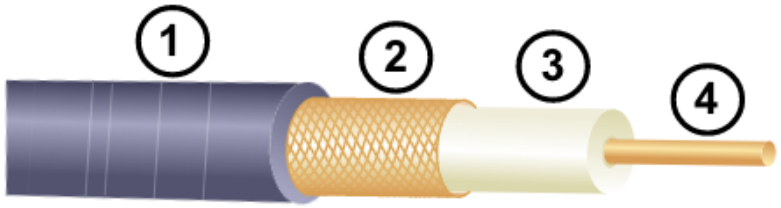
Copper cabling

Unshielded Twisted Pair (UTP)	Shielded Twisted Pair (STP)
	
Most common networking media. RJ-45 connectors. Twisted pairs protect the signal from interference.	Better noise protection, more expensive, harder to install. EMI/RFI protection

Coaxial cable

Commonly used in the following situations:

- **Wireless installations:** attach antennas to wireless devices
- **Cable internet installations:** customer premises wiring

Coaxial cable	Coaxial connectors
	

UTP Cabling

UTP relies on the following properties to limit crosstalk:

- **Cancellation:** Each wire in a pair of wires uses opposite polarity. One wire is negative, the other wire is positive. They are twisted together and the magnetic fields effectively cancel each other and outside EMI/RFI.
- **Variation in twists per foot in each wire:** Each wire is twisted a different amount, which helps prevent crosstalk amongst the wires in the cable.

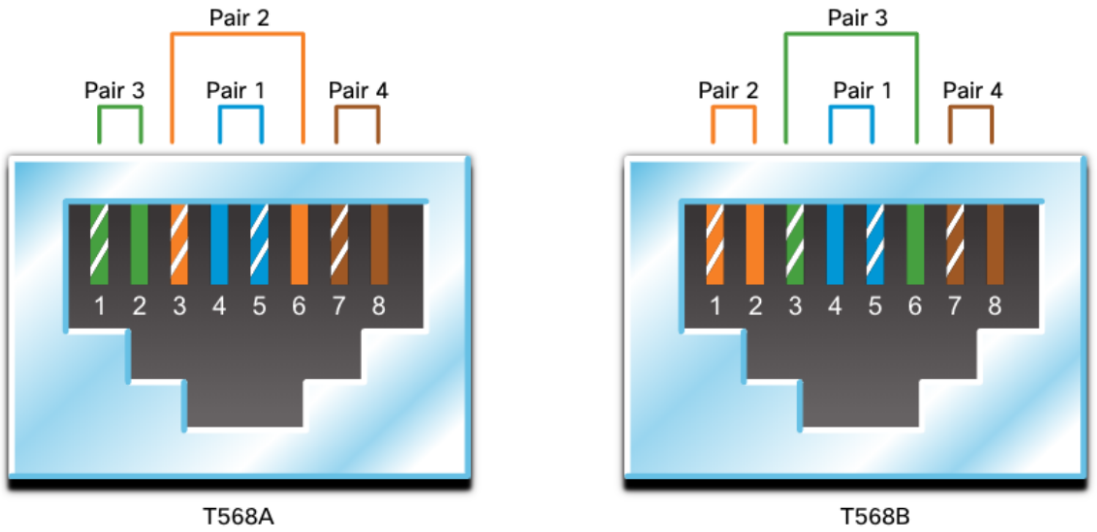
Standard TIA/EIA-568:

- Cable Types, cable lengths, connectors (RJ-45), cable termination, testing methods

Standard IEEE: Performance

- Cat 3, Cat 5 (100Mbps), Cat 5e (1Gbps), Cat 6/7 (10Gbps), Cat 8 (40Gbps)

Straight-through and Crossover UTP Cables



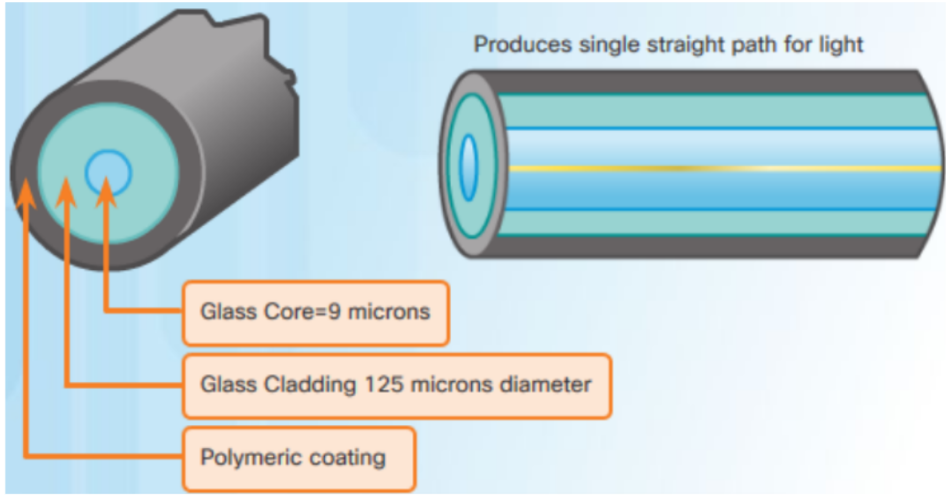
Cable Type	Standard	Application
Ethernet Straight-through	Both ends T568A or T568B	Host to Network Device
Ethernet Crossover *	One end T568A, other end T568B	Host-to-Host, Switch-to-Switch, Router-to-Router
* Considered Legacy due to most NICs using Auto-MDIX to sense cable type and complete connection		
Rollover	Cisco Proprietary	Host serial port to Router or Switch Console Port, using an adapter

Fiber-Optic Cabling

- Not as common as UTP because of the expense involved
- Transmits data over longer distances at higher bandwidth than any other networking media
- Less susceptible to attenuation, and completely immune to EMI/RFI
- Made of flexible, extremely thin strands of very pure glass
- Uses a laser or LED to encode bits as pulses of light
- The fiber-optic cable acts as a wave guide to transmit light between the two ends with minimal signal loss
- **Uses:** Enterprise Networks, Fiber-to-the-Home (FTTH), Long-Haul Networks and Submarine Cable Networks

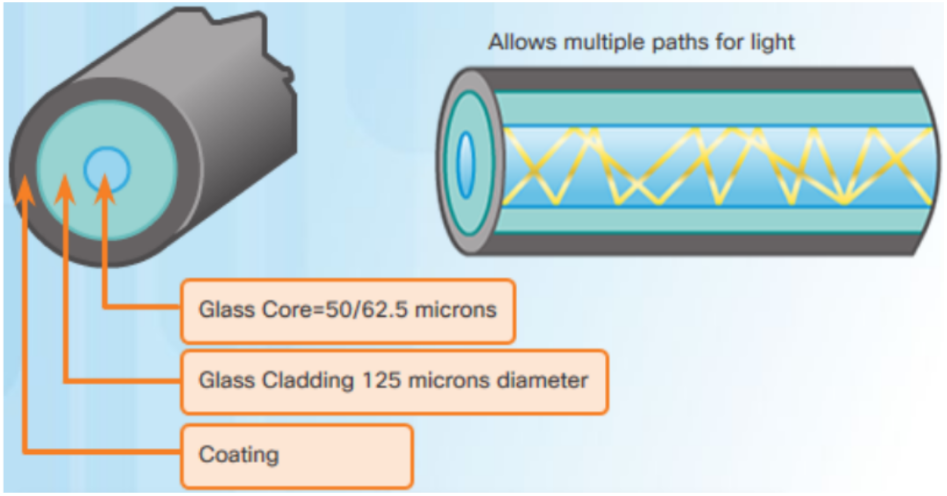
Types of Fiber Media

Single-Mode Fiber



- Very small core
- Uses expensive lasers
- Long-distance applications

Multimode Fiber



- Larger core
- Uses less expensive LEDs
- LEDs transmit at different angles
- Up to 10 Gbps over 550 meters

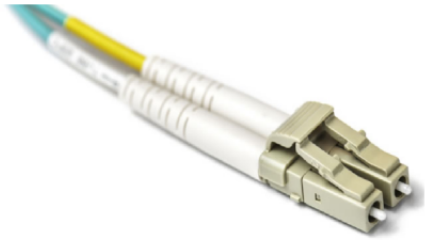
Dispersion refers to the spreading out of a light pulse over time. Increased dispersion means increased loss of signal strength. MMF has greater dispersion than SMF, with a the maximum cable distance for MMF is 550 meters.

Fiber-Optic Connectors and Patch Cords

Straight-Tip (ST) Connectors

Lucent Connector (LC) Simplex Connectors

Subscriber Connector (SC) Connectors



Duplex Multimode LC Connectors

SC-SC MM Patch Cord

LC-LC SM Patch Cord

ST-LC MM Patch Cord

ST-SC SM Patch Cord

Fiber versus Copper

Implementation Issues	UTP Cabling	Fiber-Optic Cabling
Bandwidth supported	10 Mb/s - 10 Gb/s	10 Mb/s - 100 Gb/s
Distance	Relatively short (1 - 100 meters)	Relatively long (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

Wireless Media

Limitations of wireless:

- **Coverage area:** Impacted by the physical characteristics of the location.
- **Interference:** Susceptible to interference and can be disrupted by many devices.
- **Security:** Anyone can gain access to the transmission.
- **Shared medium:** WLANs operate in half-duplex, which means only one device can send or receive at a time. Many users ➡️ reduced bandwidth for each user.

Standards: Wi-Fi (IEEE 802.11), Bluetooth (IEEE 802.15), WiMAX (IEEE 802.16), Zigbee (IEEE 802.15.4)

Devices: Wireless Access Point (AP), Wireless NIC Adapters