Chapter 4: Network Access

Introduction to Networks

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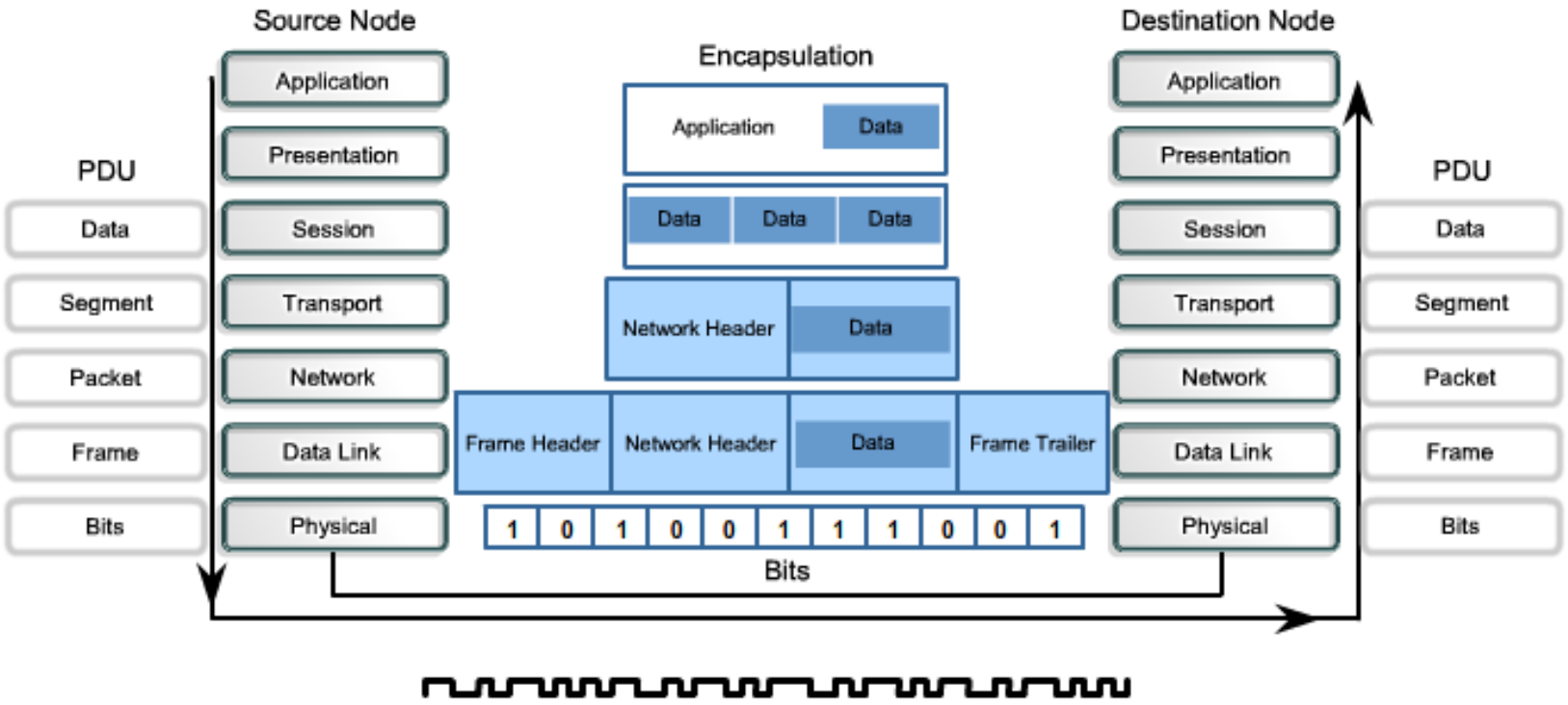
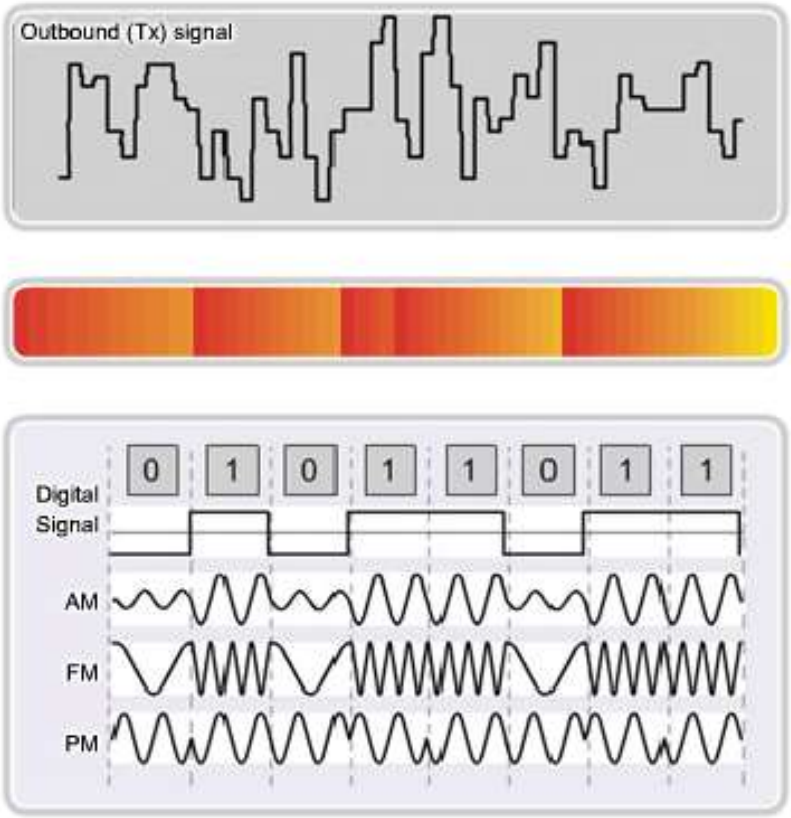
Chapter 4

The Physical Layer



In diagrams, signals on the physical media are depicted by this line symbol.

Physical Layer Media



Sample electrical signals transmitted on copper cable

Representative light pulse fiber signals

Microwave (wireless) signals

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

Physical Layer Fundamental Principles

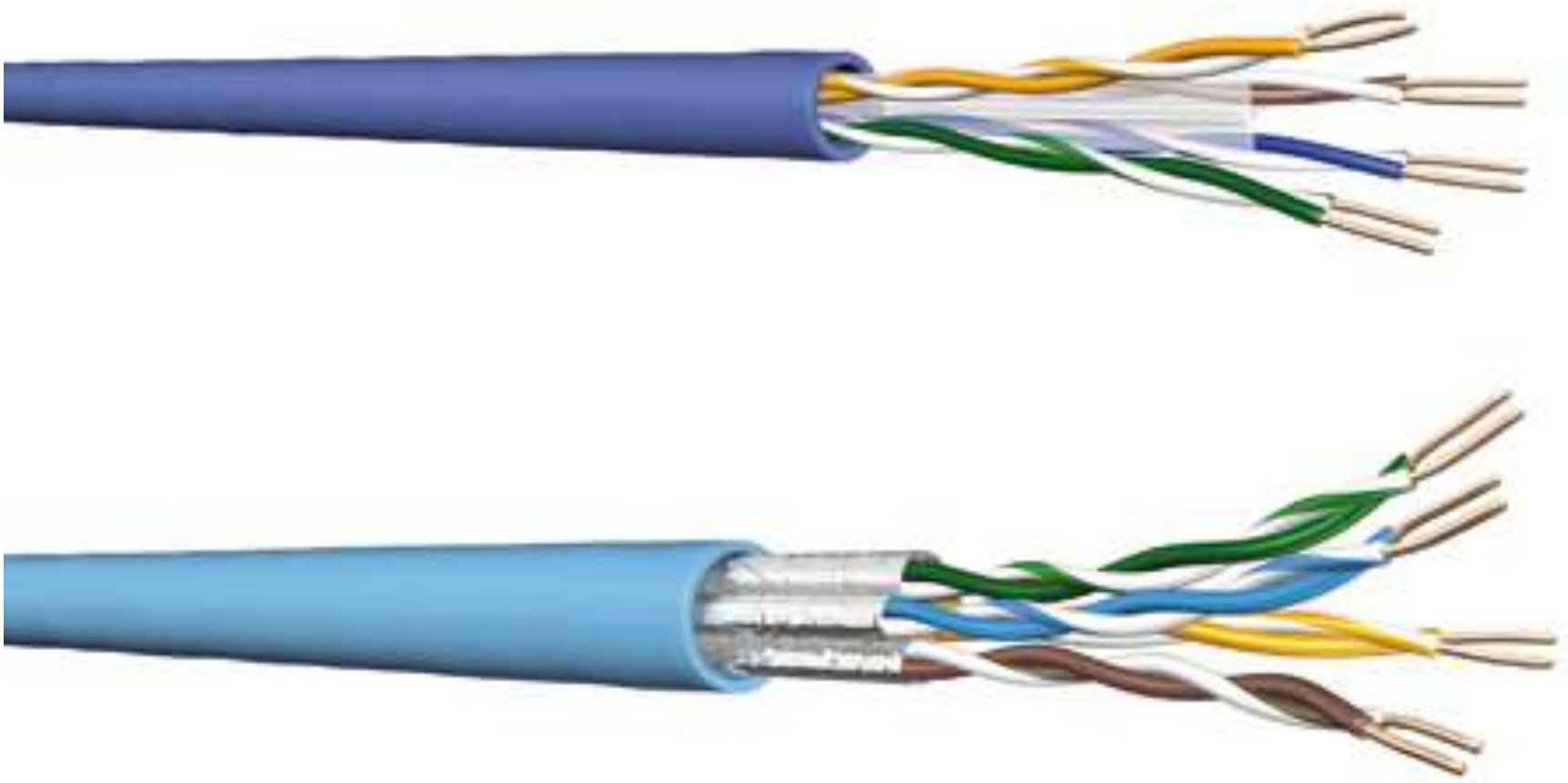
Media	Physical Components	Frame Encoding Technique	Signalling Method
Copper cable	• UTP • Coaxial • Connectors • NICs • Ports • Interfaces	• Manchester Encoding • Non-Return to Zero (NRZ) techniques • 4B/5B codes are used with Multi-Level Transition Level 3 (MLT-3) signaling • 8B/10B • PAM5	• Changes 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

Bandwidth

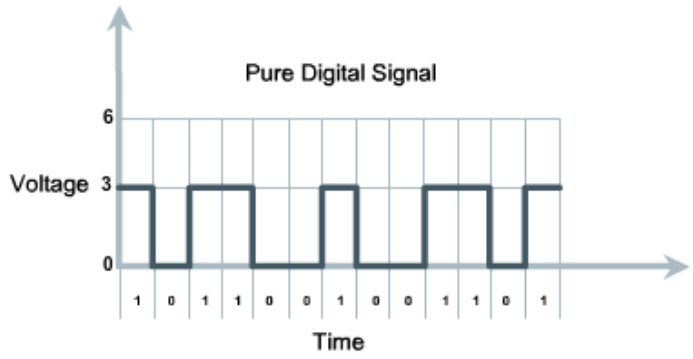
Unit of Bandwidth	Abbreviation	Equivalence
Bits per second	bps	1 bps = fundamental unit of bandwidth
Kilobits per second	kbps	1 kbps = 1,000 bps = 10^3 bps
Megabits per second	Mbps	1 Mbps = 1,000,000 bps = 10^6 bps
Gigabits per second	Gbps	1 Gbps = 1,000,000,000 bps = 10^9 bps
Terabits per second	Tbps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

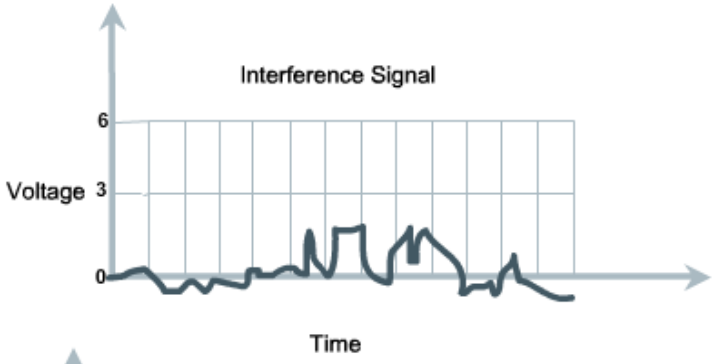
Throughput

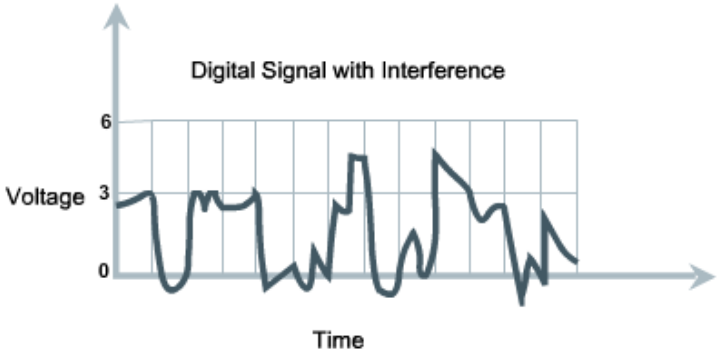
Copper Cabling

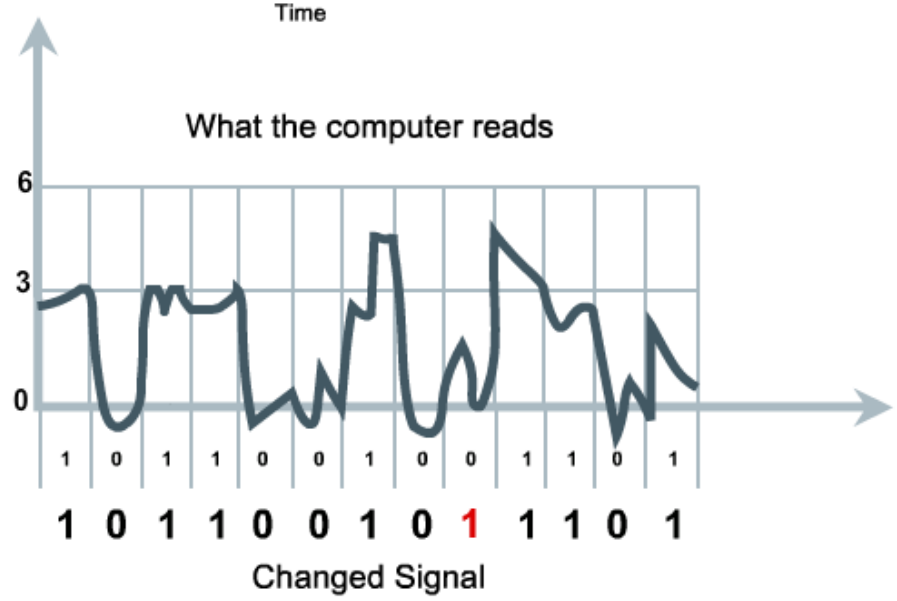


Characteristics of Copper Media

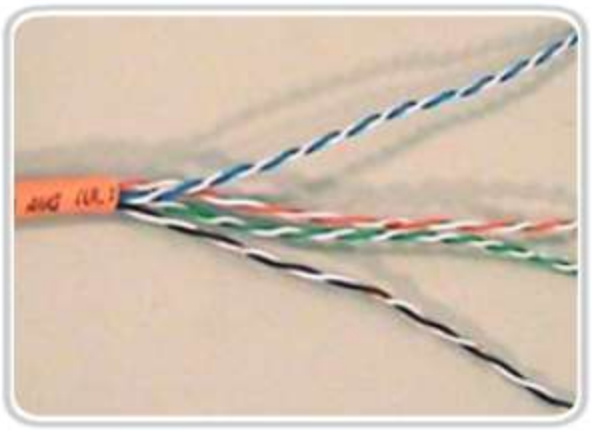






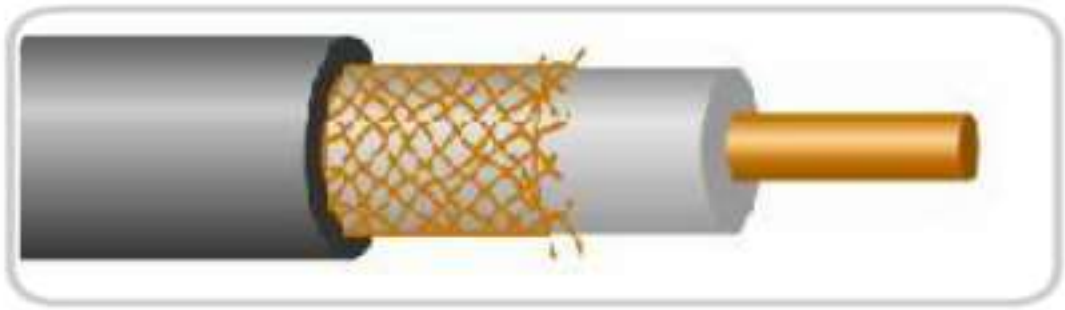


Copper Media



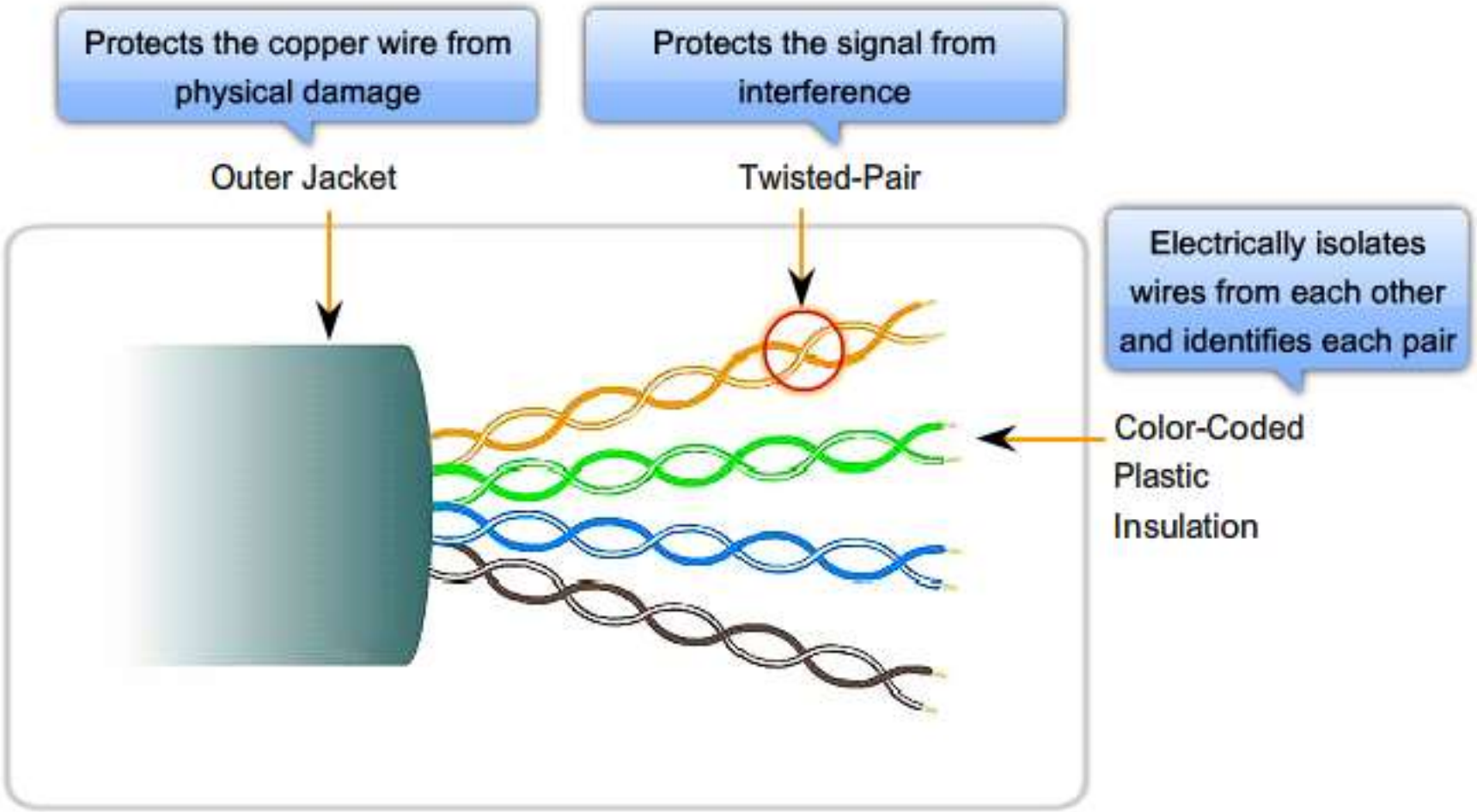
Unshielded Twisted Pair (UTP) cable

Shielded Twisted Pair (STP) cable

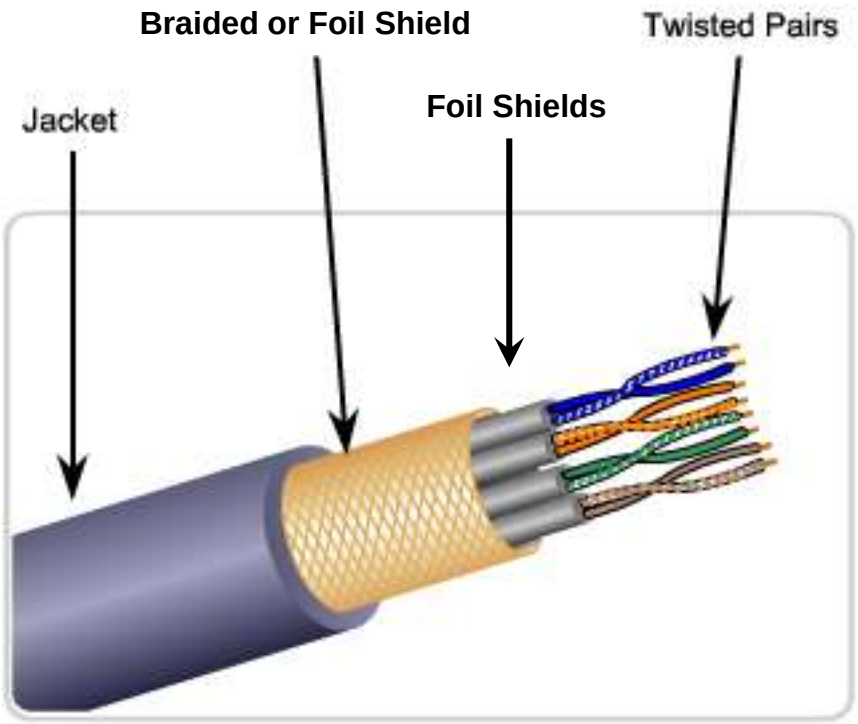


Coaxial cable

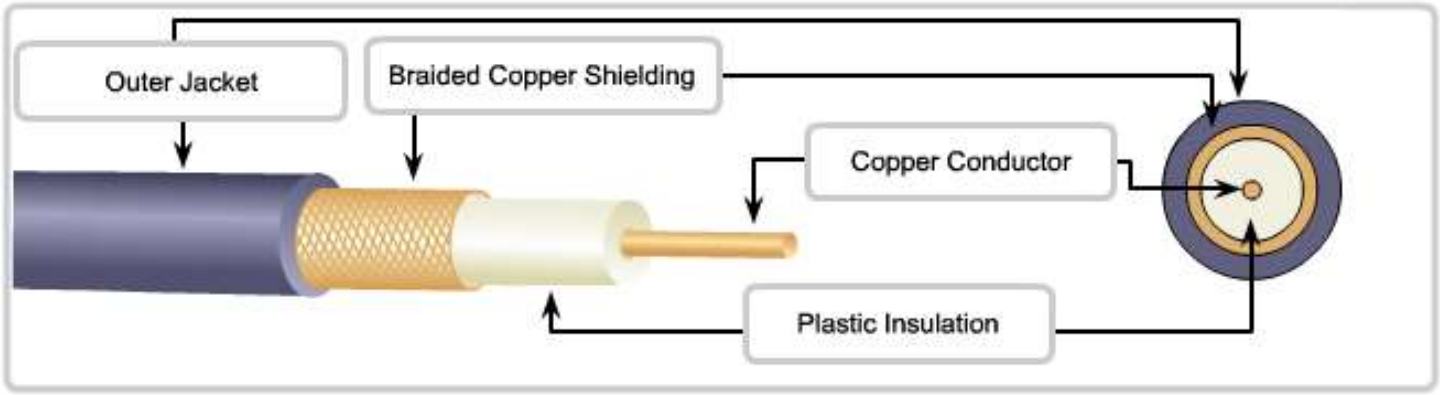
Unshielded Twisted-Pair (UTP) Cable



Shielded Twisted-Pair (STP) Cable



Coaxial Cable



Cooper Media Safety

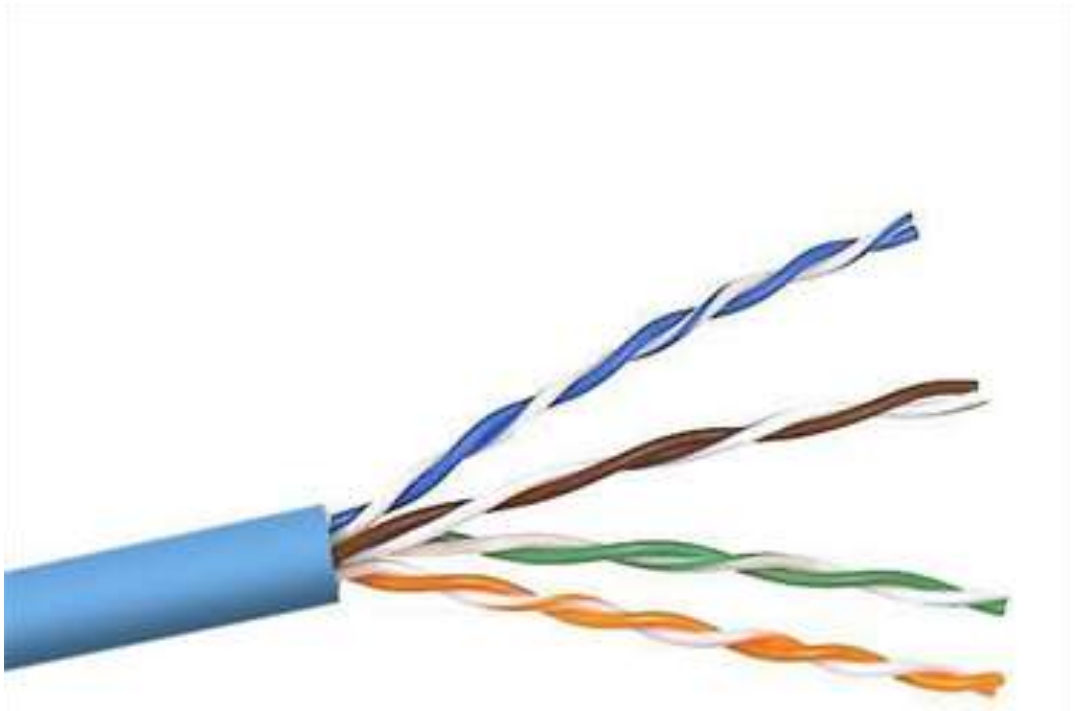
The separation of data and electrical power cabling must comply with safety codes.

Cables must be connected correctly.

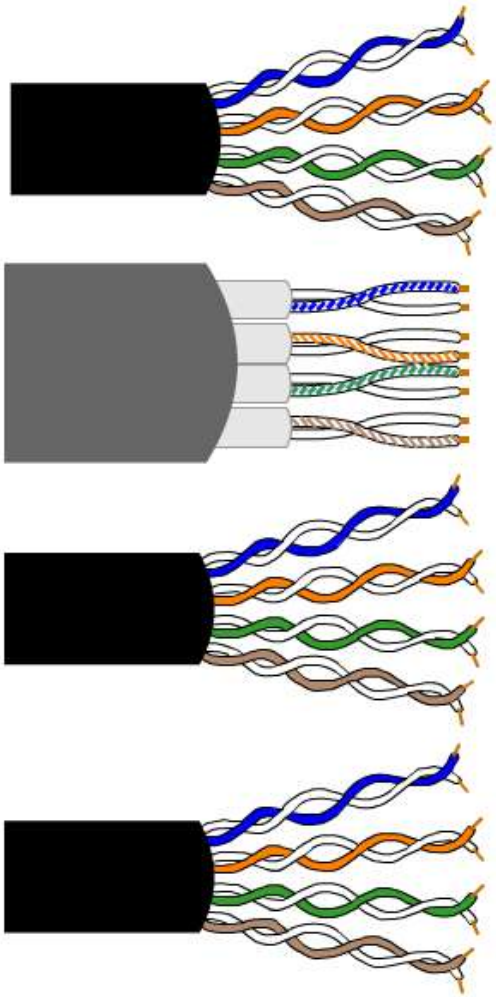
Installations must be inspected for damage.

Equipment must be grounded correctly.

Properties of UTP Cabling



UTP Cabling Standards



Category 3 Cable (UTP)

Category 7 Cable (ScTP)

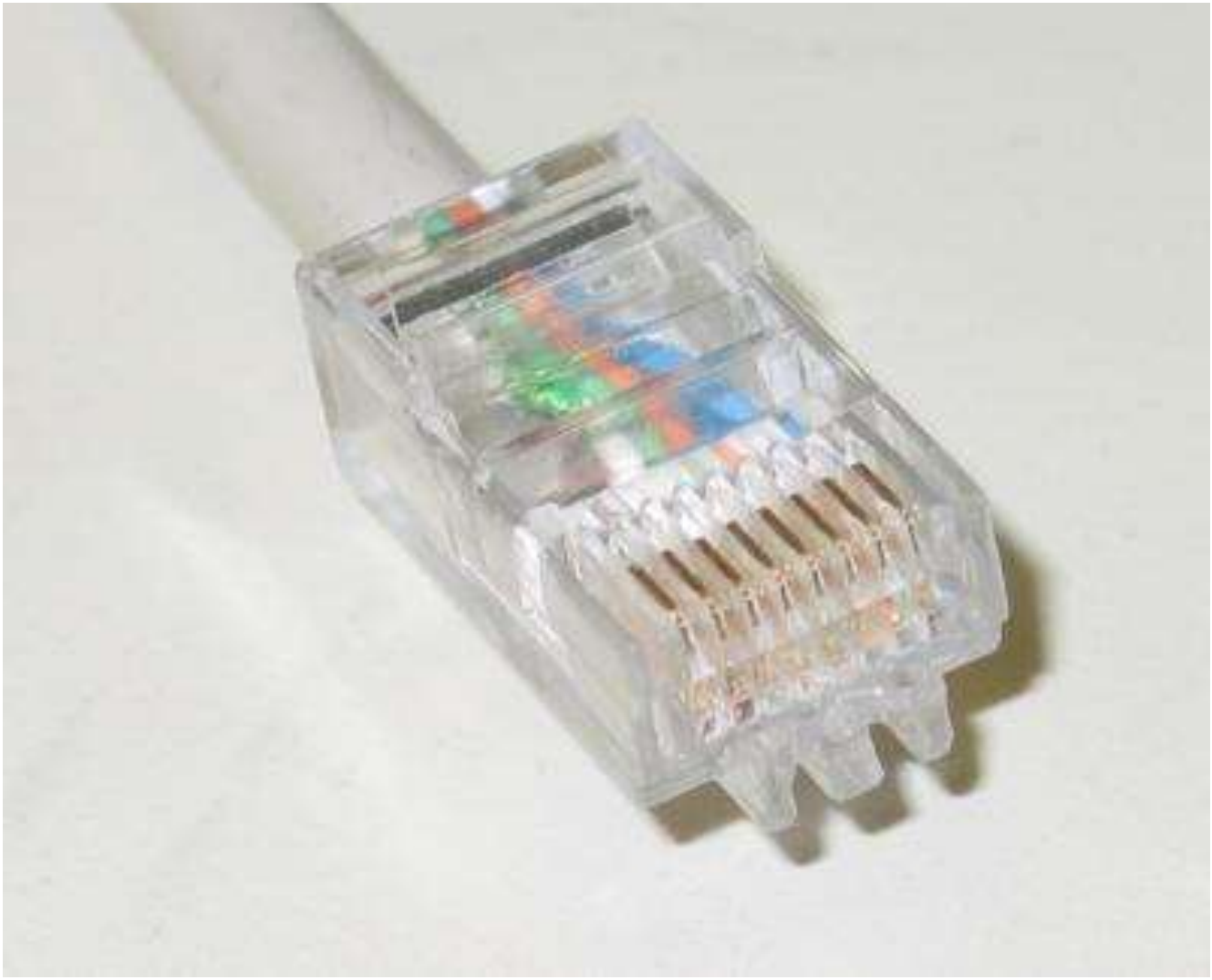
Category 6 Cable (UTP)

Category 5 and 5e Cable (UTP)

Category 5 and 5e Cable (UTP)

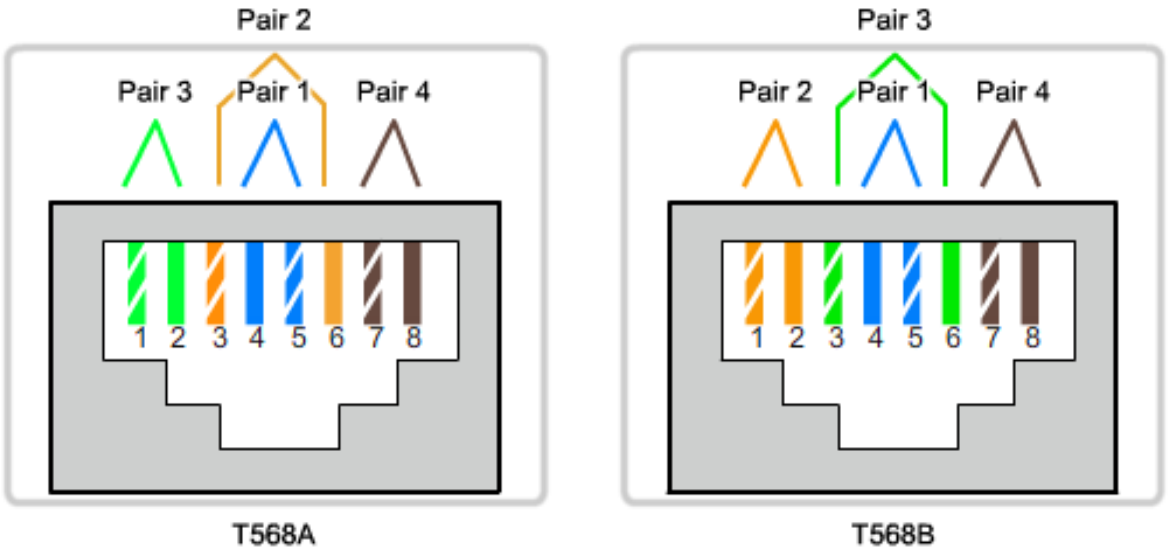
- Used for Data transmission
- Cat 5 supports 100 Mbps and can support 1000 Mbps but it is not recommended
- Cat 5e supports 1000 Mbps

UTP Connectors



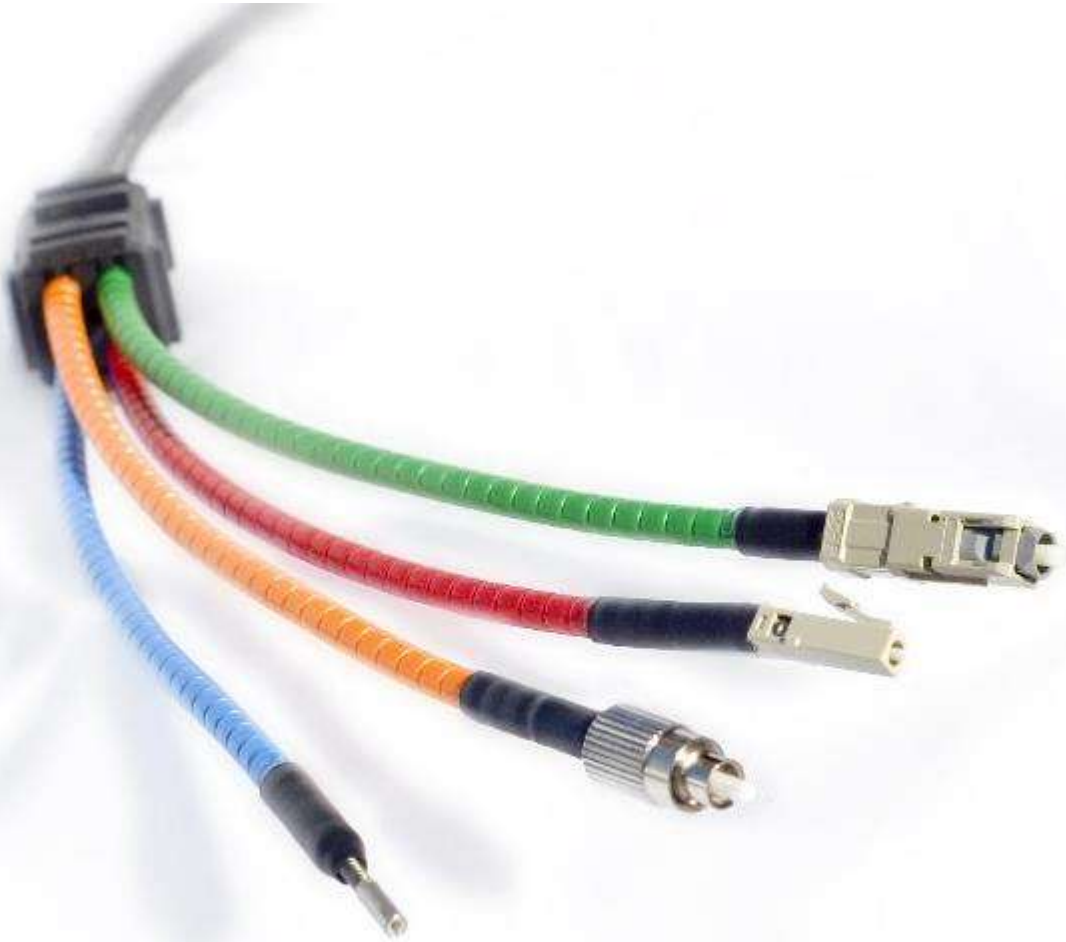
Types of UTP Cable

Cable Type	Standard	Application
Ethernet Straight-through	Both ends T568A or both ends 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.

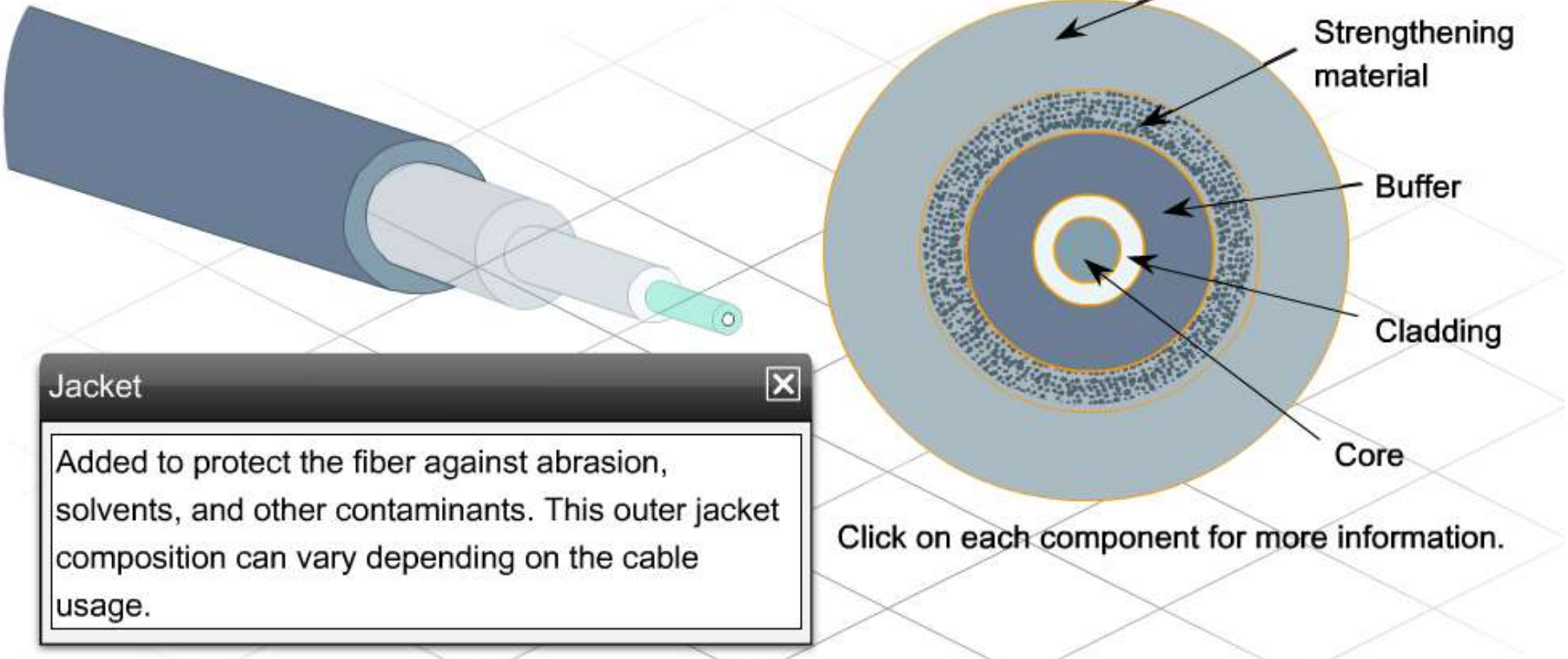


Testing UTP Cables

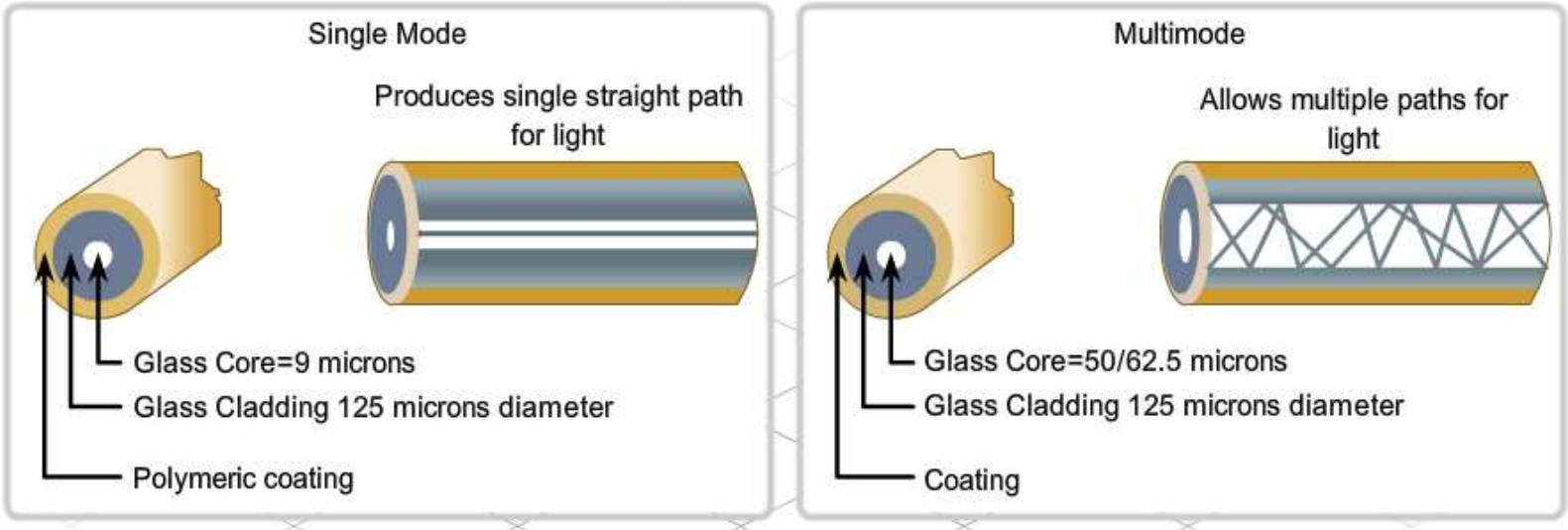
Properties of Fiber Optic Cabling



Fiber Media Cable Design



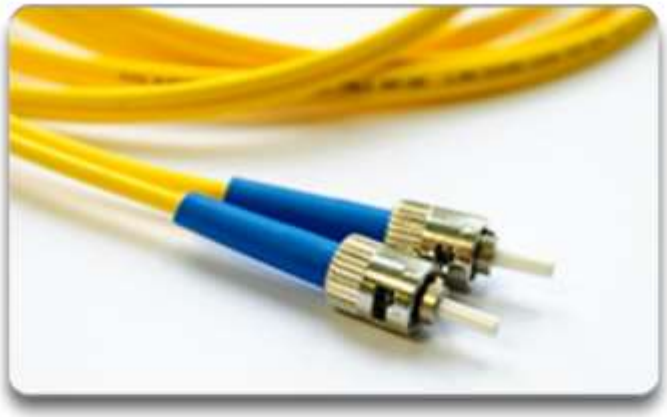
Types of Fiber Media



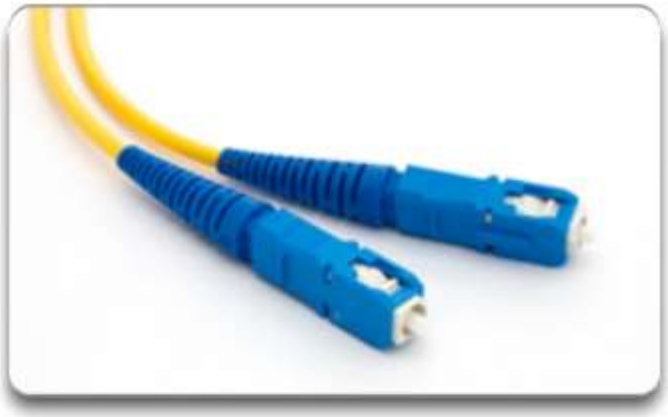
- Small Core
- Less Dispersion
- Suited for long distance applications
- Uses lasers as the light source
- Commonly used with campus backbones for distances of several thousand meters

- Larger core than single mode cable
- Allows greater dispersion and therefore, loss of signal
- Suited for long distance applications, but shorter than single mode
- Uses LEDs as the light source
- Commonly used with LANs or distances of a couple hundred meters within a campus network

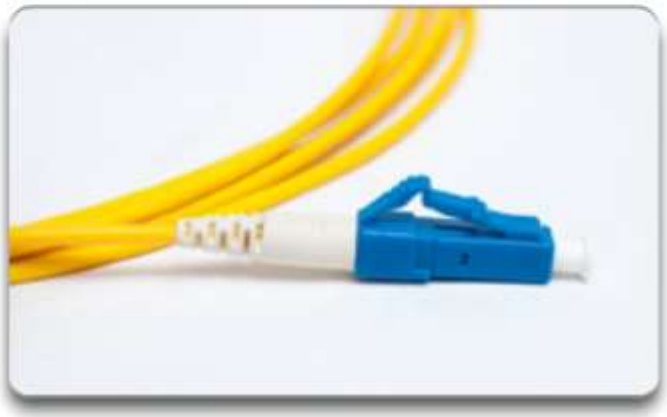
Network Fiber Connectors



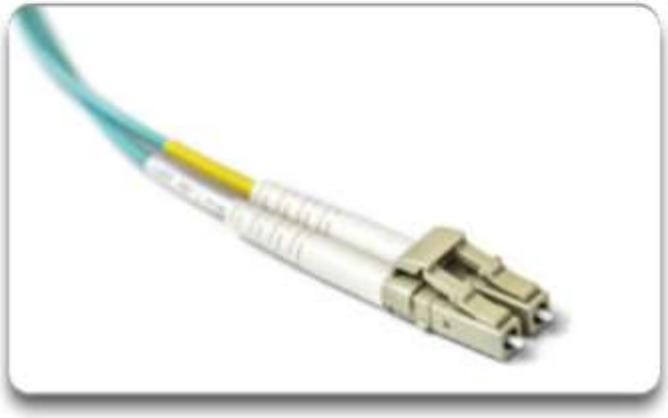
ST Connectors



SC Connectors



LC Connector



Duplex Multimode LC Connectors

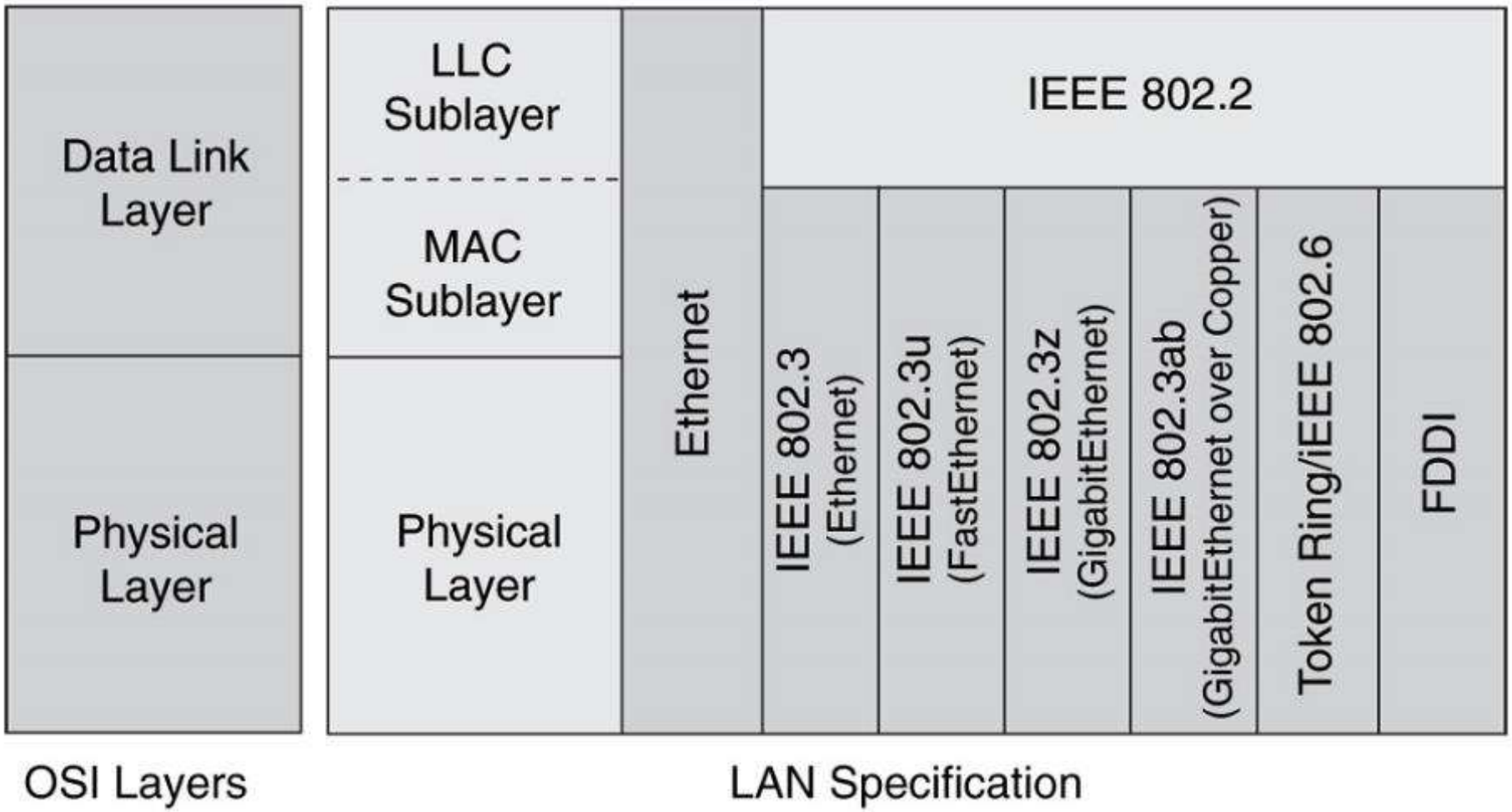
Testing Fiber Cables

Optical Time Domain Reflectometer (OTDR)

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

Layer 2 Standards

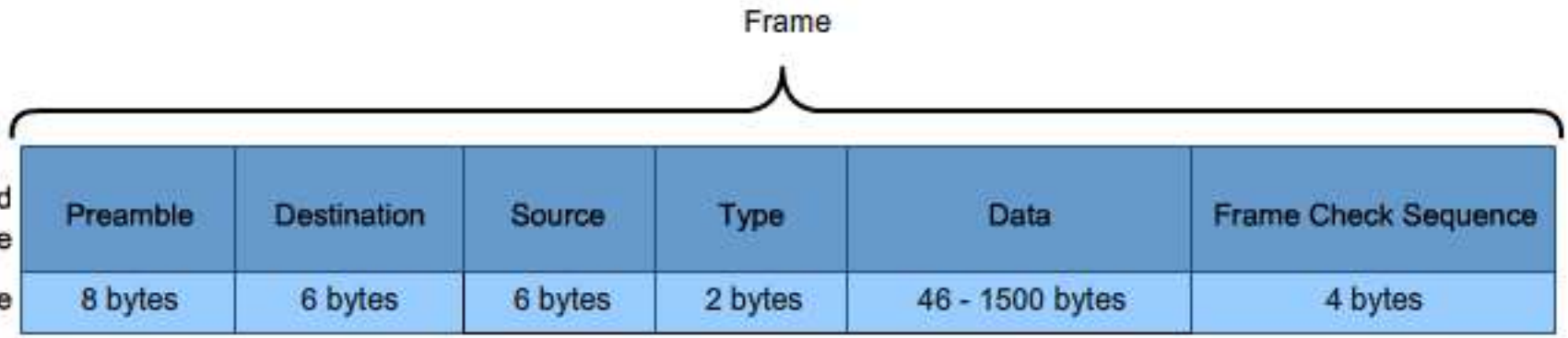


Data Link Layer Standards

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)

Ethernet Frame

A Common Data Link Layer Protocol for LANs



Preamble - used for synchronization; also contains a delimiter to mark the end of the timing information.
Destination Address - 48 bit MAC address for the destination node.
Source Address- 48 bit MAC address for the source node.
Type - value to indicate which upper layer protocol will receive the data after the Ethernet process is complete.
Data or payload - this is the PDU, typically an IPv4 packet, that is to be transported over the media.
Frame Check Sequence (FCS) - A value used to check for damaged frames.

802.11 Wireless Frame