Chapter 4: Network Access

OSI Physical Layer

Chapter 4 - Scope

1 Physical Layer Protocols

2 Network Media

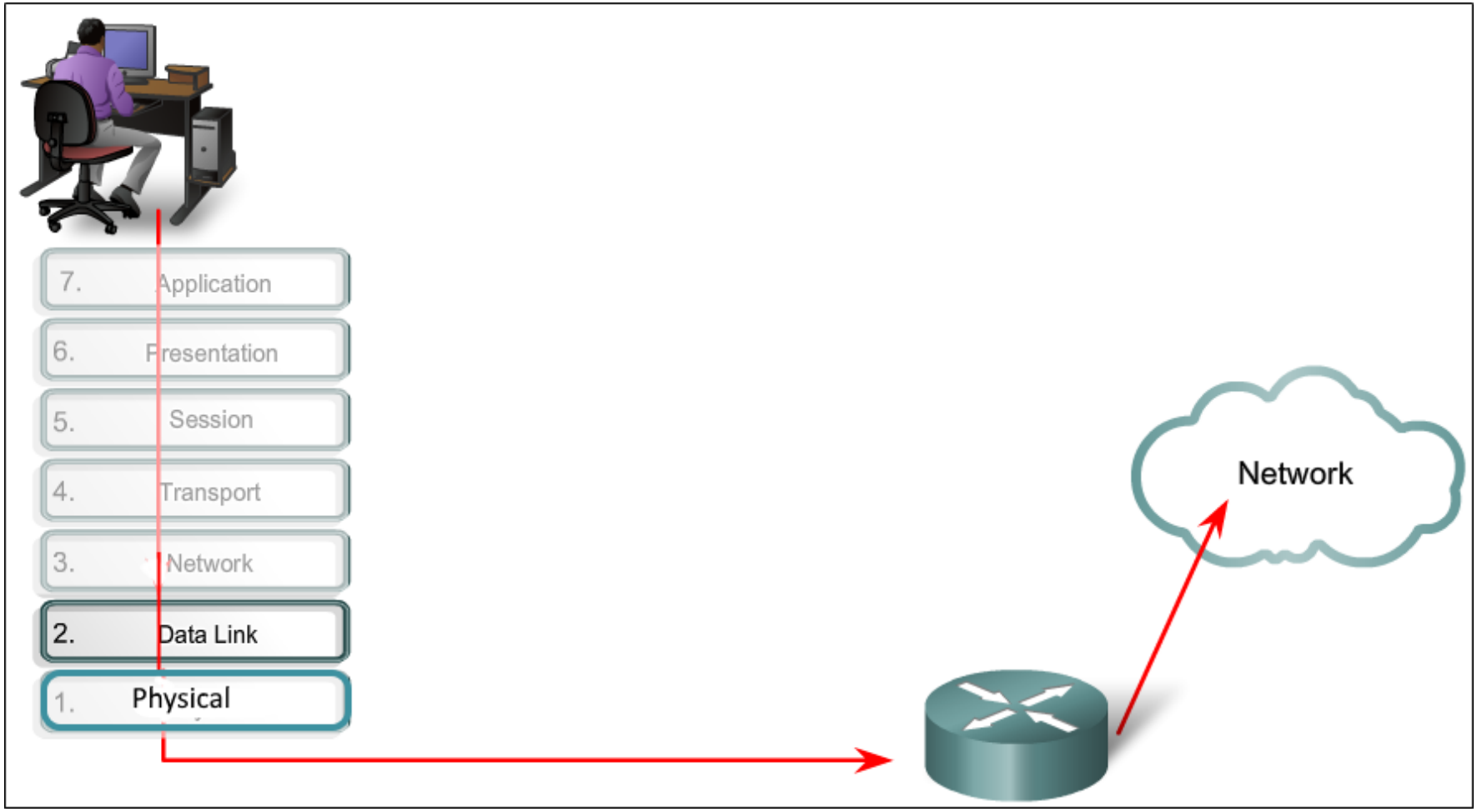
3 Data Link Layer Protocols

4 Media Access Control

5 Summary

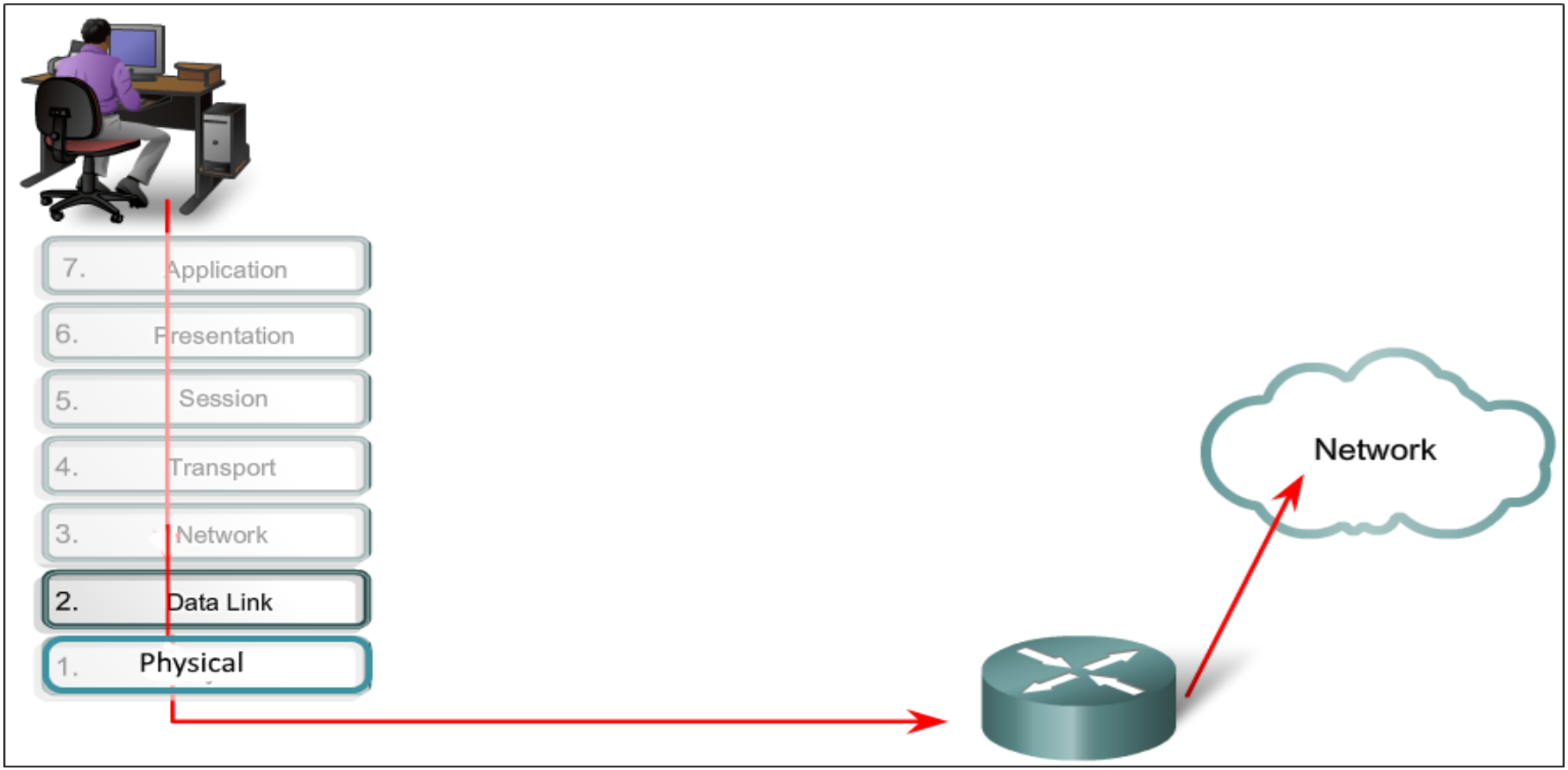
Open System Interconnection (OSI)

The OSI has 7 layers.
Data sent from an end device will travel through the layers to reach a network.



OSI Physical layer

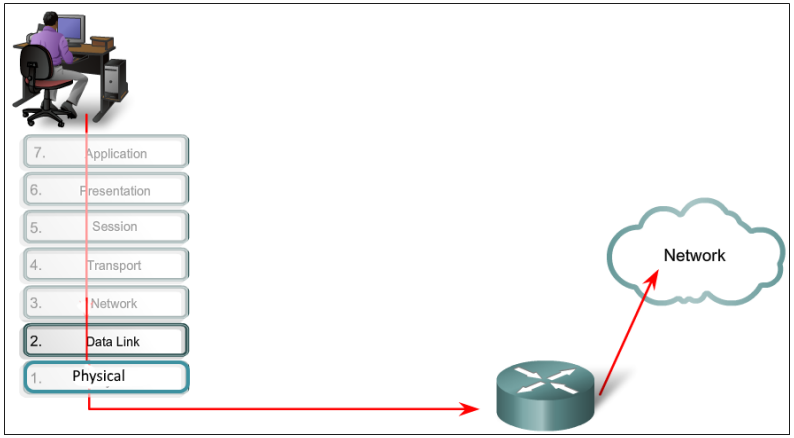
The first layer is known as the Physical Layer.



OSI Physical layer

Characteristics of the Physical Layer

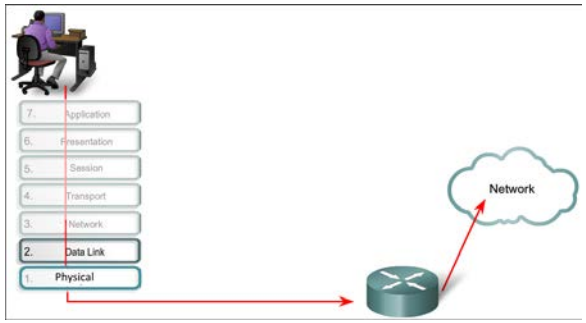
- Lowest layer
- Consists of basic networking hardware
- Defines how bits of information are transmitted



OSI Physical layer

Hardware used include:

- Routers (wired and wireless)
- Switches
- Modems
- Cables
- Range extenders
- Repeaters



OSI Physical Layer - Standards

For systems to work all over the world, some standards must be adhered to.

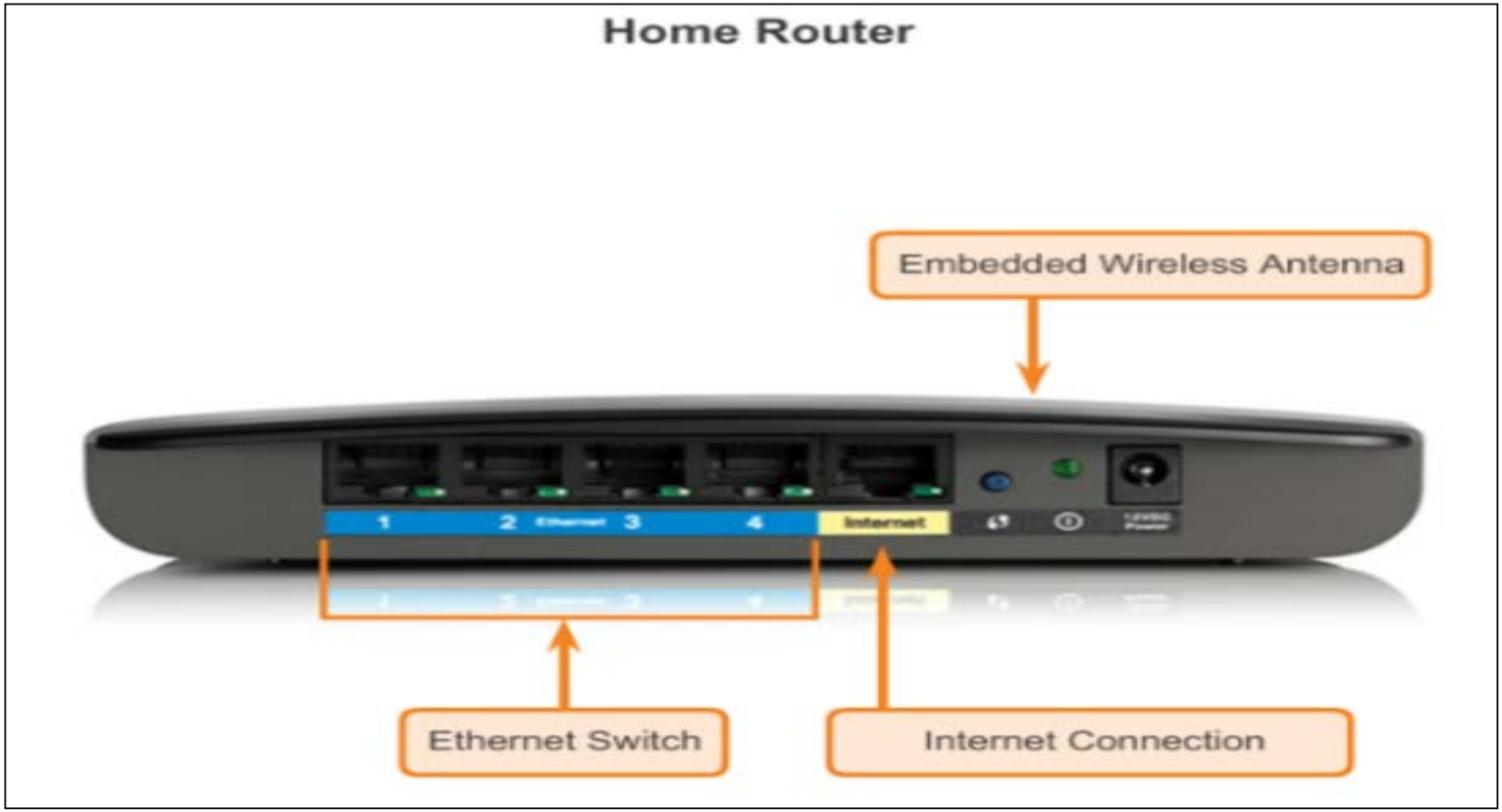
There are 5 standards used for the Physical Layer.

OSI 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

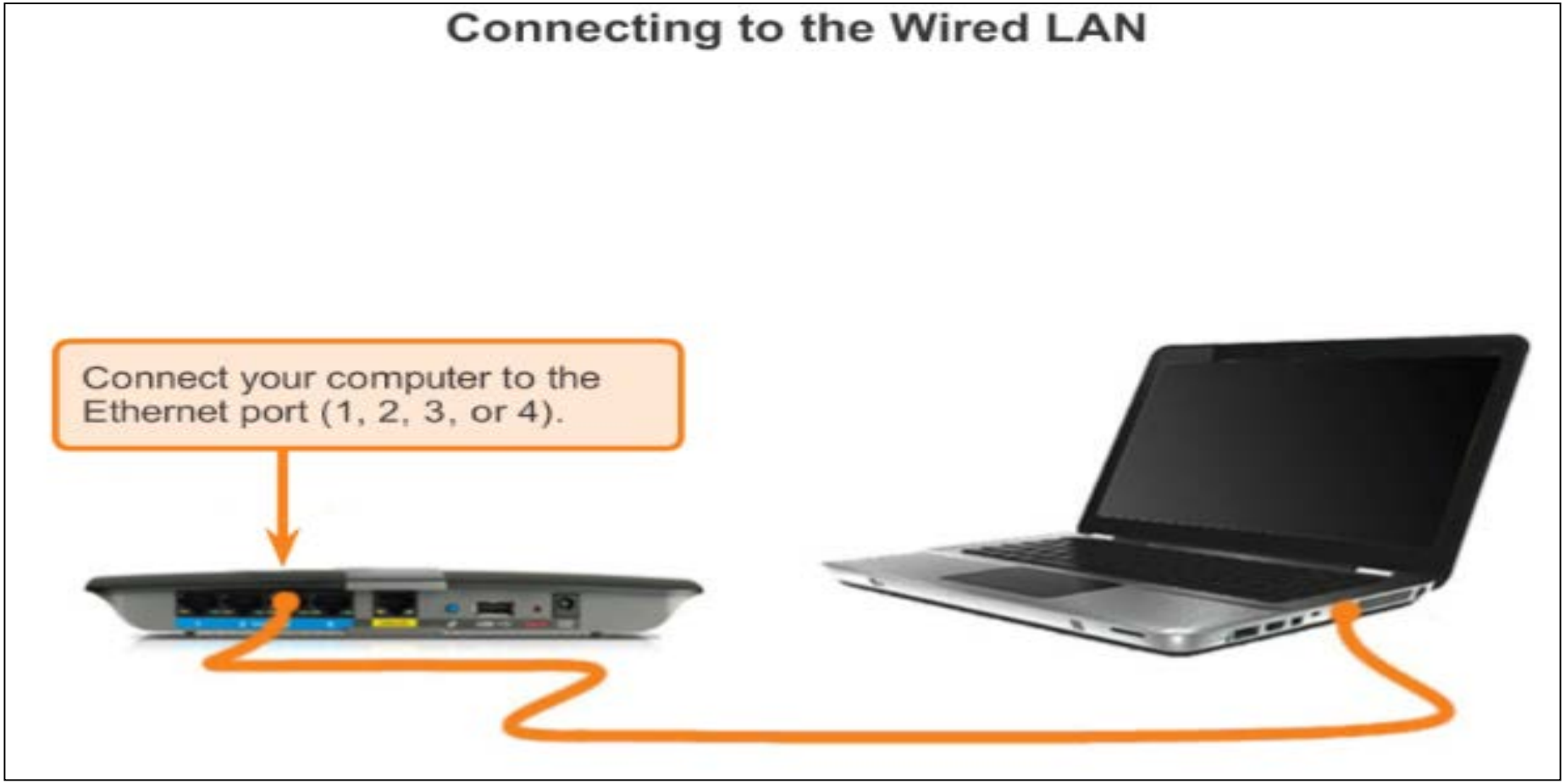
OSI Physical Layer

A router is used to allow devices to be connected physically to the internet.



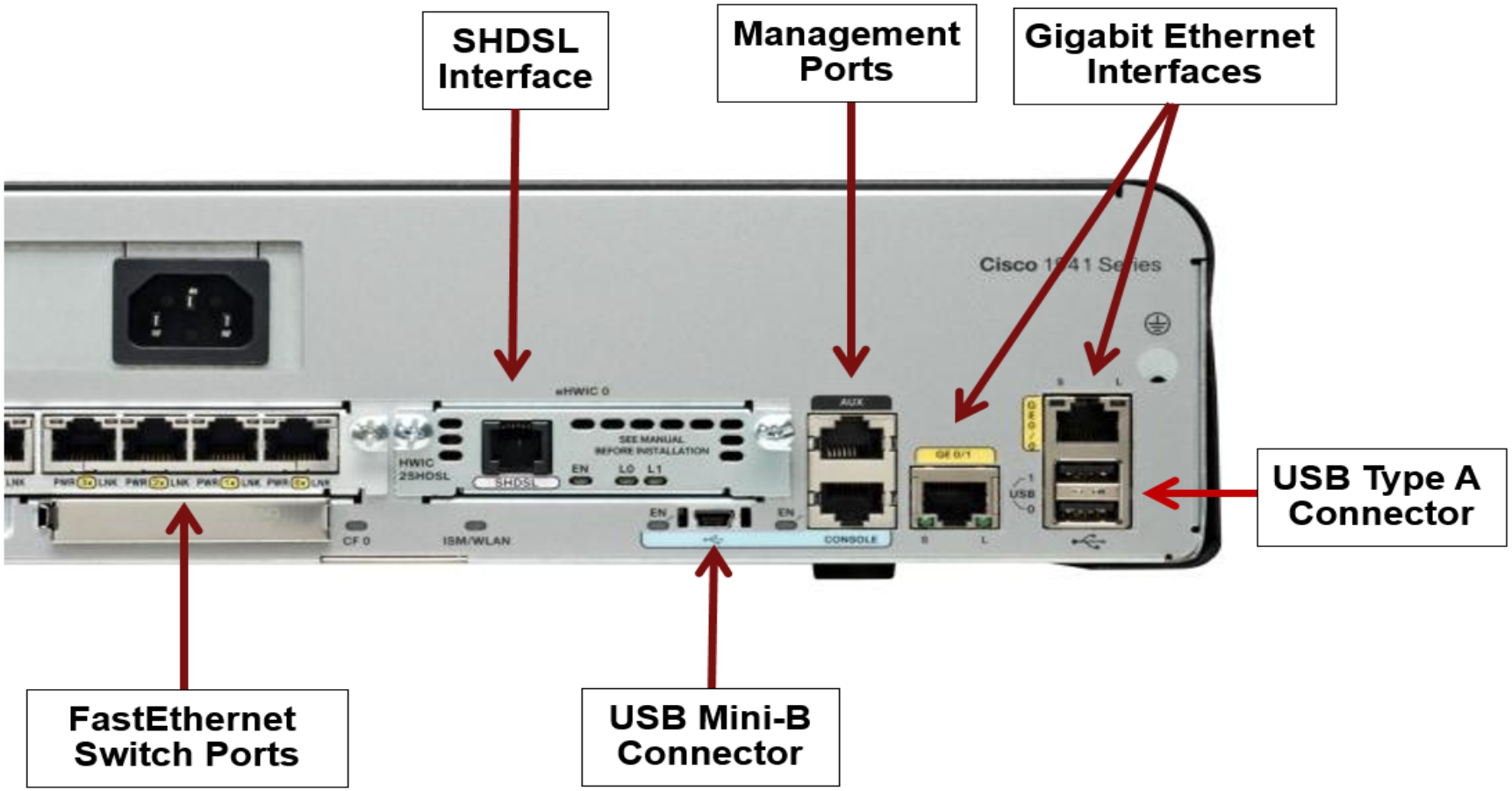
OSI Physical Layer

Wired connection is achieved using cables.



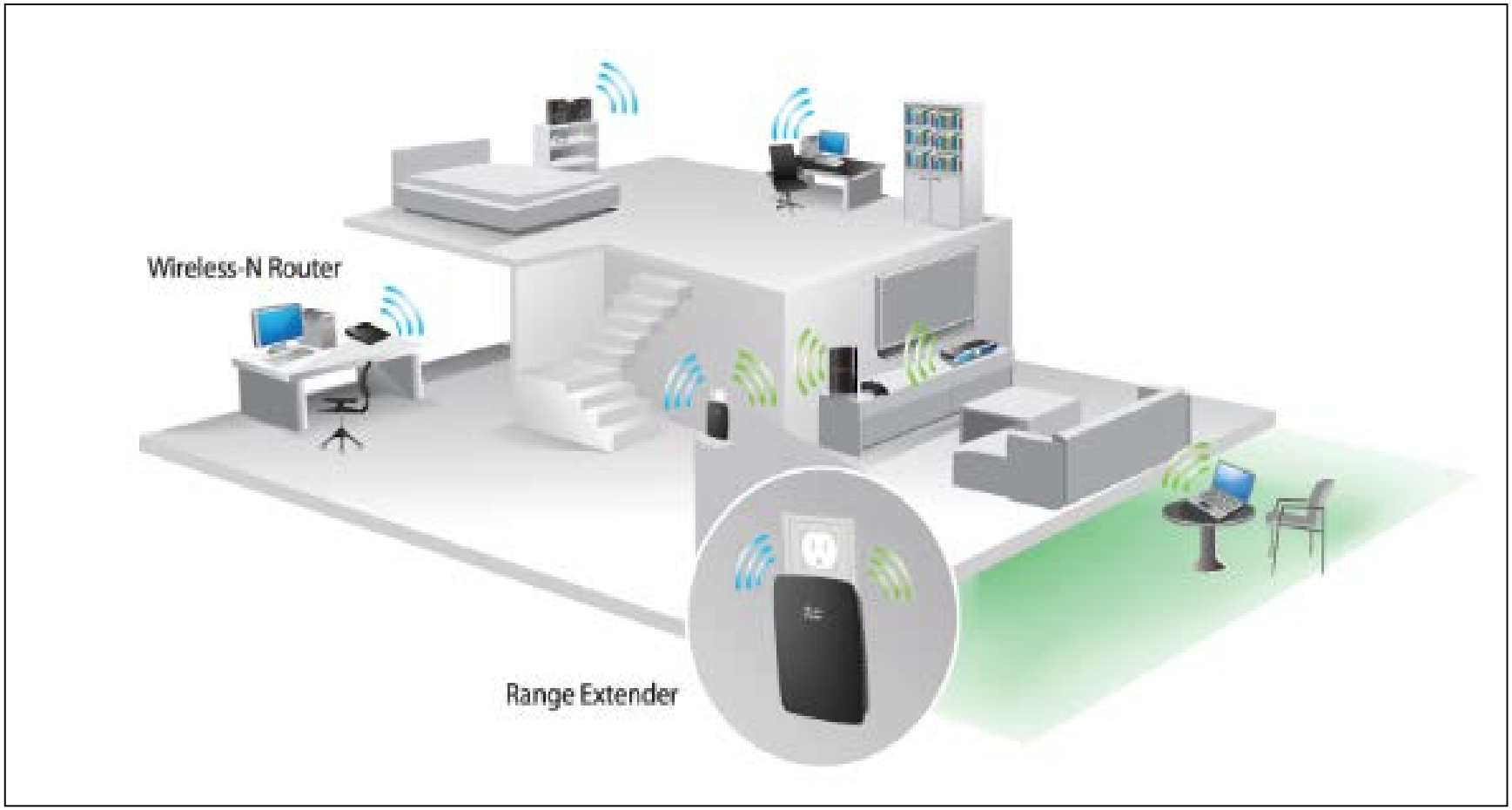
OSI Physical Layer - Types of Physical Media

Different ports are used for different functions.



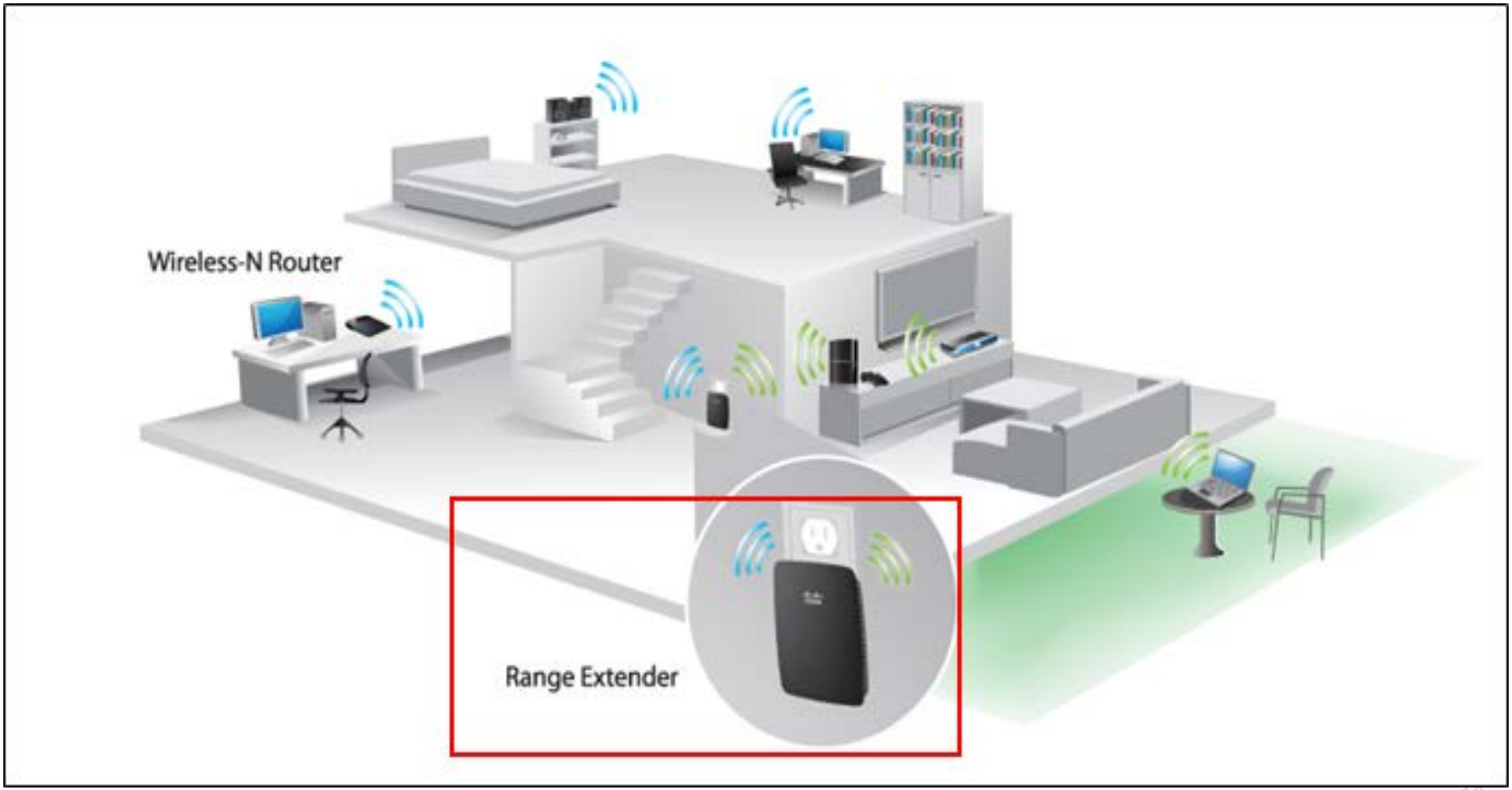
OSI Physical Layer

Wireless connection is achieved using Wireless routers.



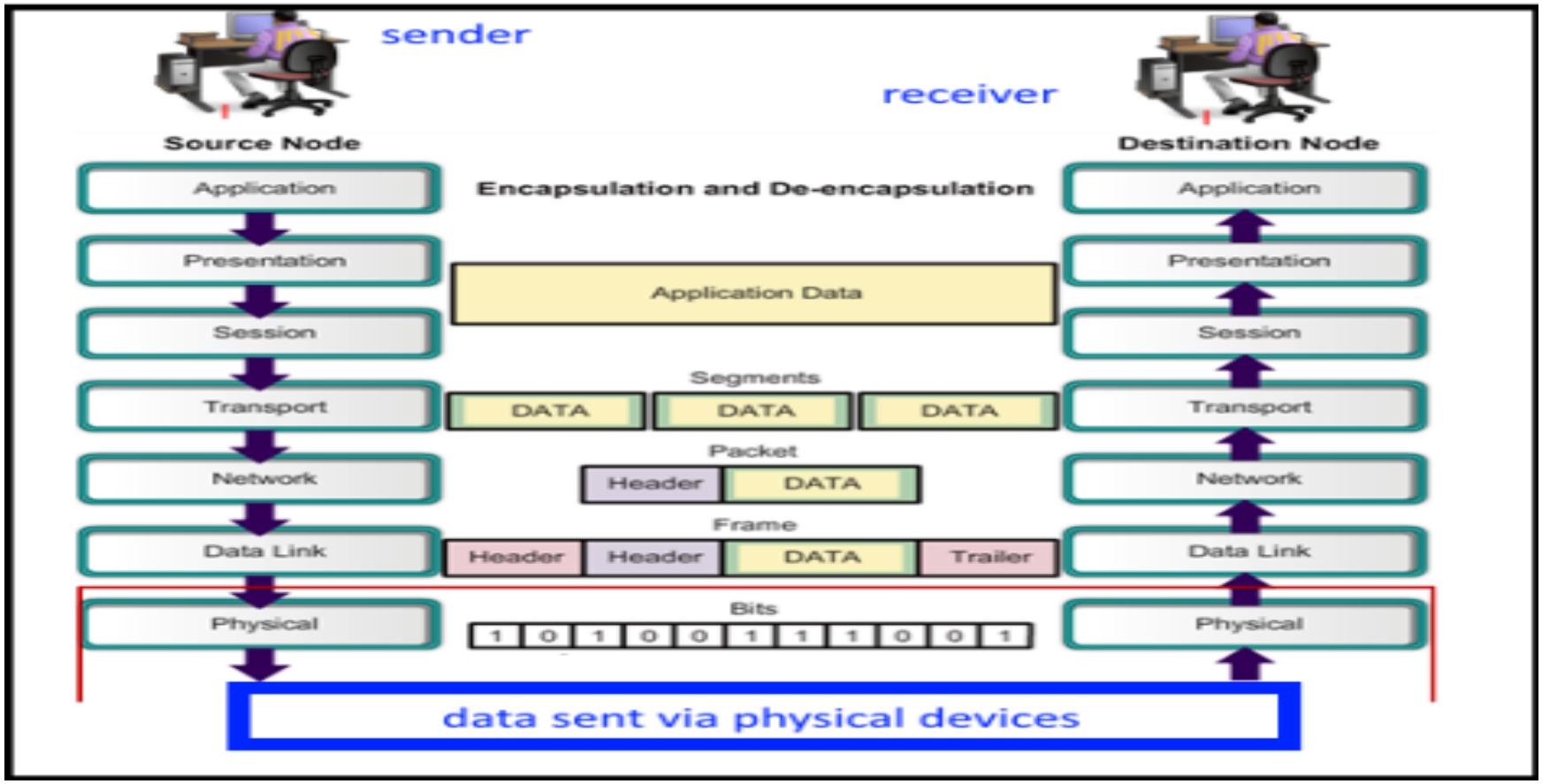
OSI Physical Layer

Wireless transmission has range limitations.
For devices out of range, range extenders can be used



OSI The Physical Layer

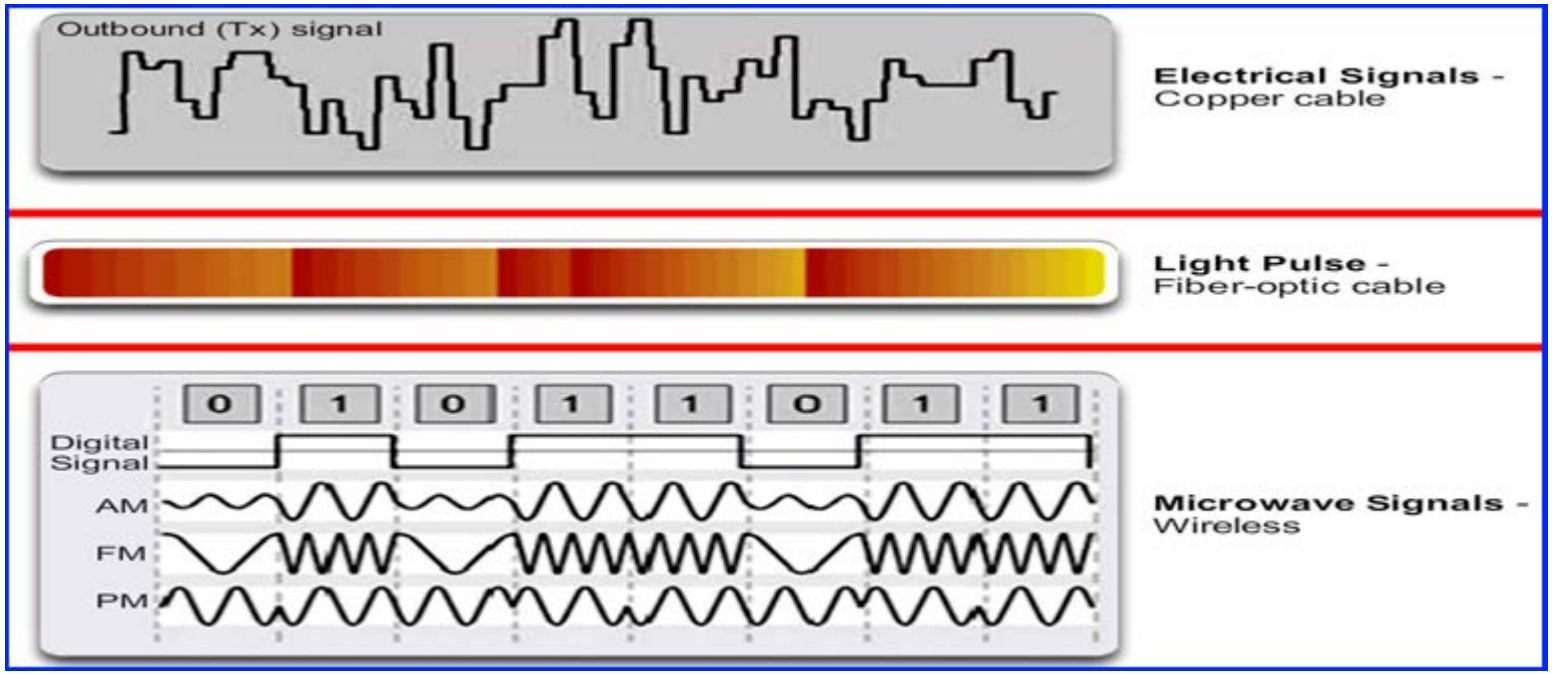
The Physical Layer allows data to be transmitted from one node to another node.



OSI Physical Layer - Media

Data are transmitted from one device to another via 3 media:

- Copper cable (electrical signals)
- Fibre-optic cable (light pulses)
- Microwave signals (microwave signals)



OSI Physical layer - Bandwidth

Bandwidth refers to speed of data transmission. Different medium offers different bandwidths.

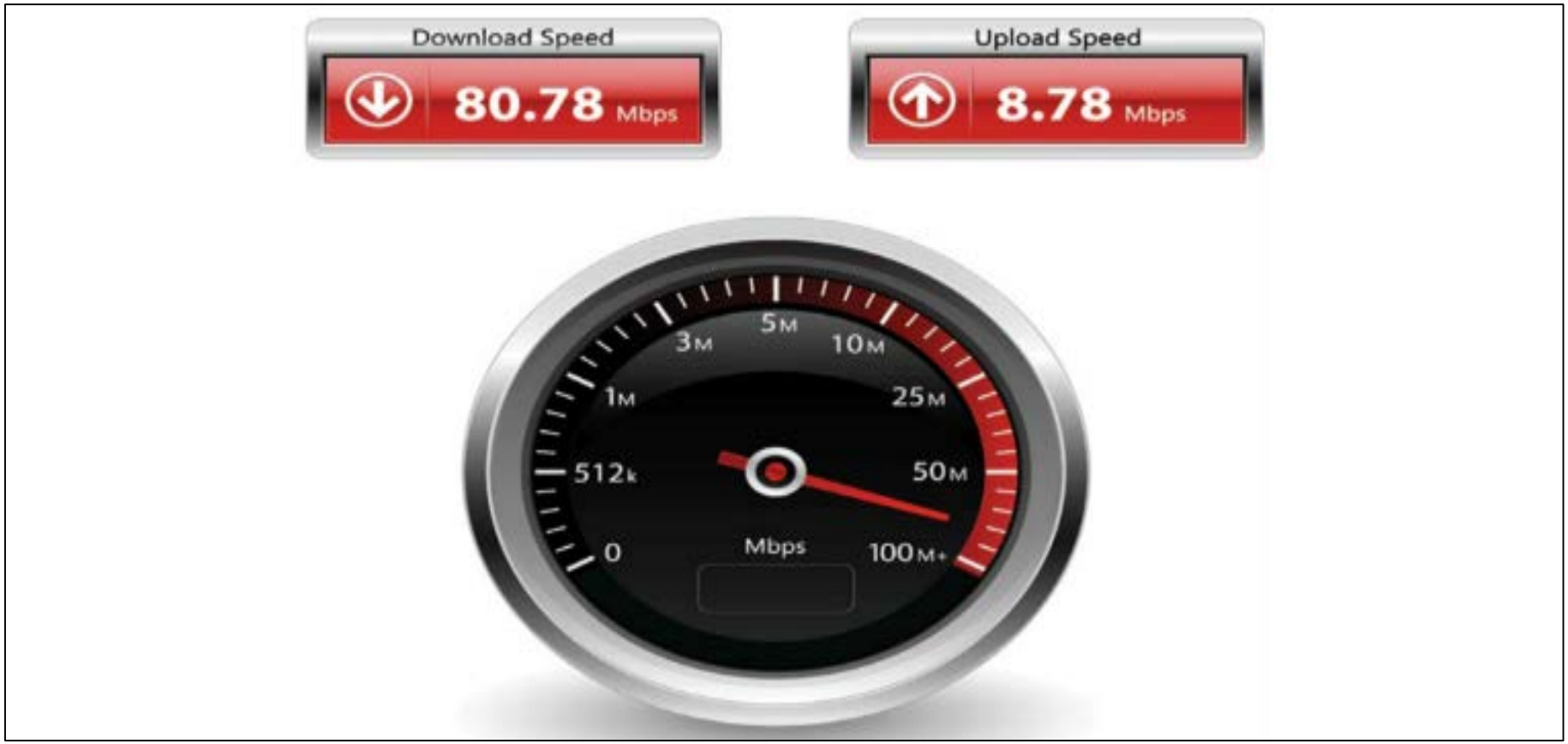
Greater bandwidth means,

- more data can be transmitted in a given time
- faster downloading
- fast uploading
- faster streaming

Unit of Bandwidth	Abbreviation	Equivalence
Bits per second (lowest)	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

OSI Physical Layer - Throughput

- In reality, data transmission speed does not reach maximum.
- The actual speed is known as throughput.
- A broadband rated at 1GB/s may operated at 600MB/s.



OSI Physical Layer – Data Transmission Media

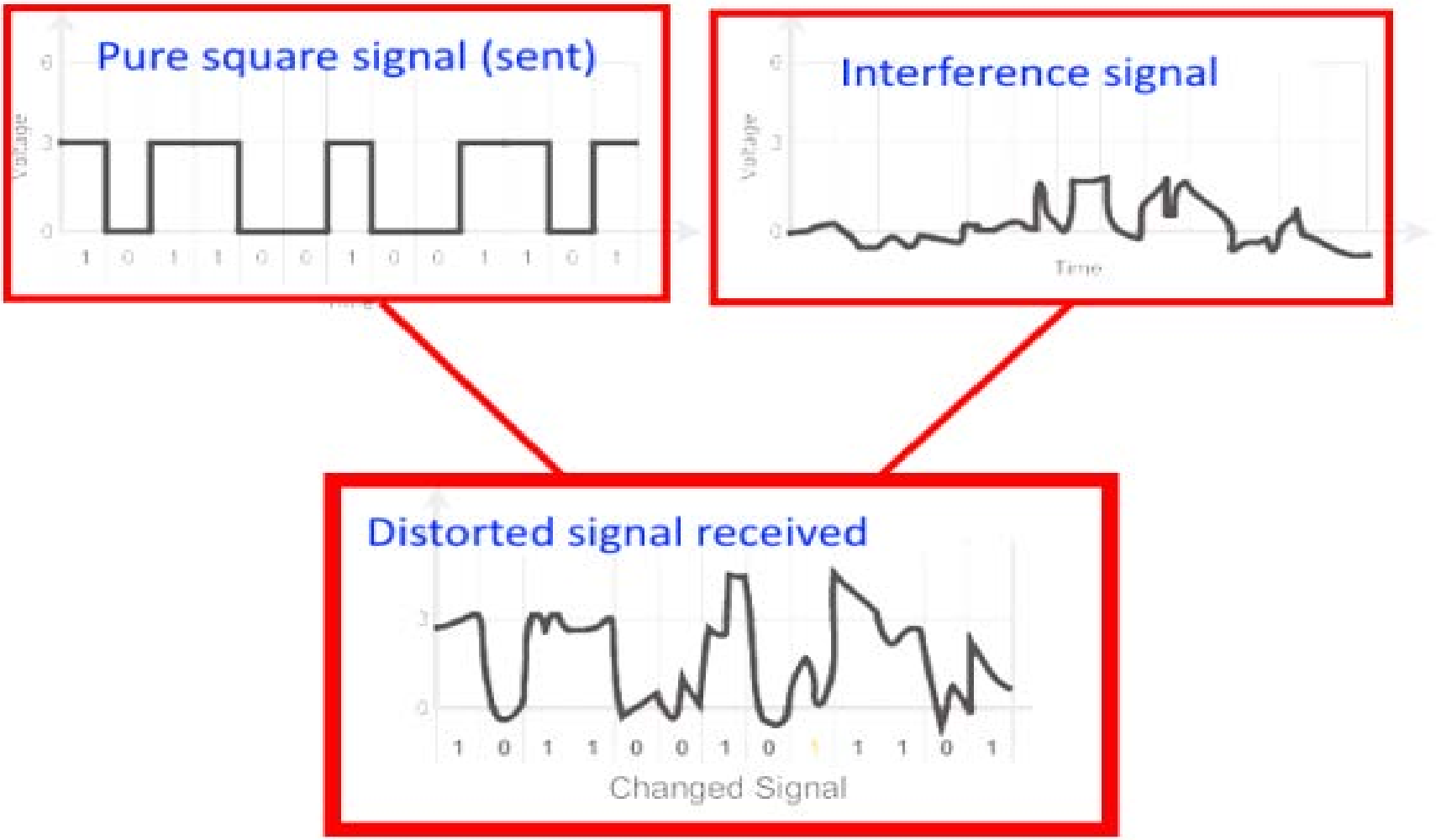
Comparison of the 3 media types:

Media	Physical Components	Frame Encoding Technique	Signalling Method
1 **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
2  **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.
3 **Wireless Media**	• Access Points • NICs • Radio • Antennae	• DSSS (direct-sequence spread-spectrum) • OFDM (orthogonal frequency division multiplexing)	• Radio waves

OSI Physical Layer – Network Copper Media

- Digital data are sent as 1 or zero through copper wires
- They are in the form of pulses
- When sent, they are pure square pulses
- But when received, they get distorted
- A small amount of distortion is acceptable
- Too much distortion means the received data cannot be read as intelligible information

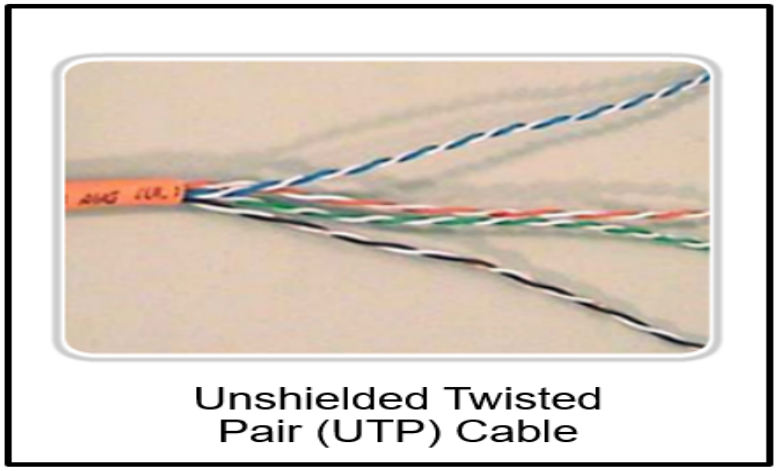
OSI Physical Layer – Network Copper Media

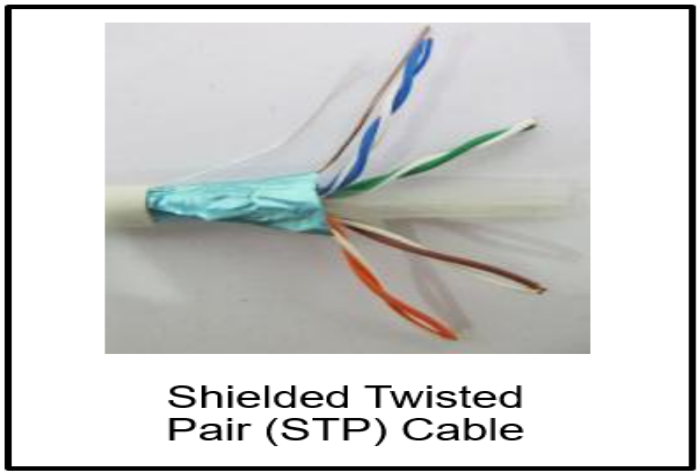


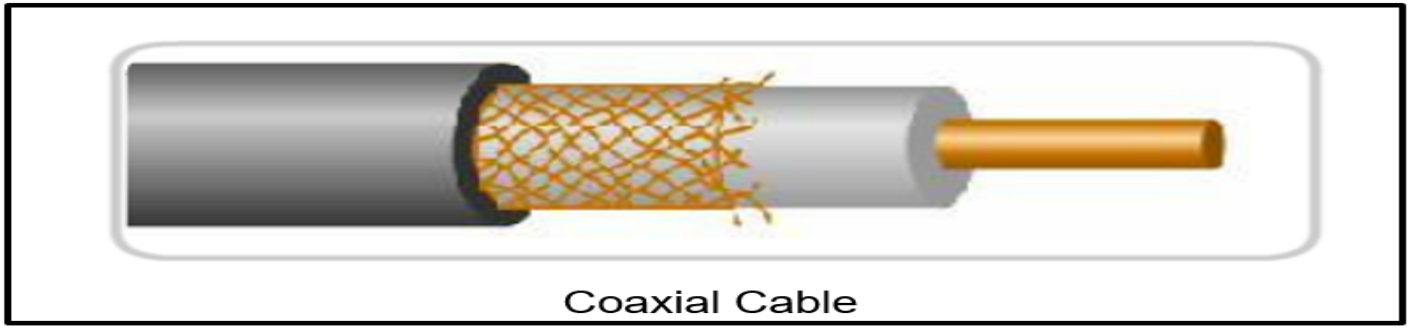
OSI Physical Layer – Network Copper Media

Three types of copper cables used are:

- Unshielded Twisted Pair (UTP) Cable
- Shielded Twisted Pair (STP) Cable
- Coaxial Cable







OSI Physical Layer – Network Media
Cooper Media Safety

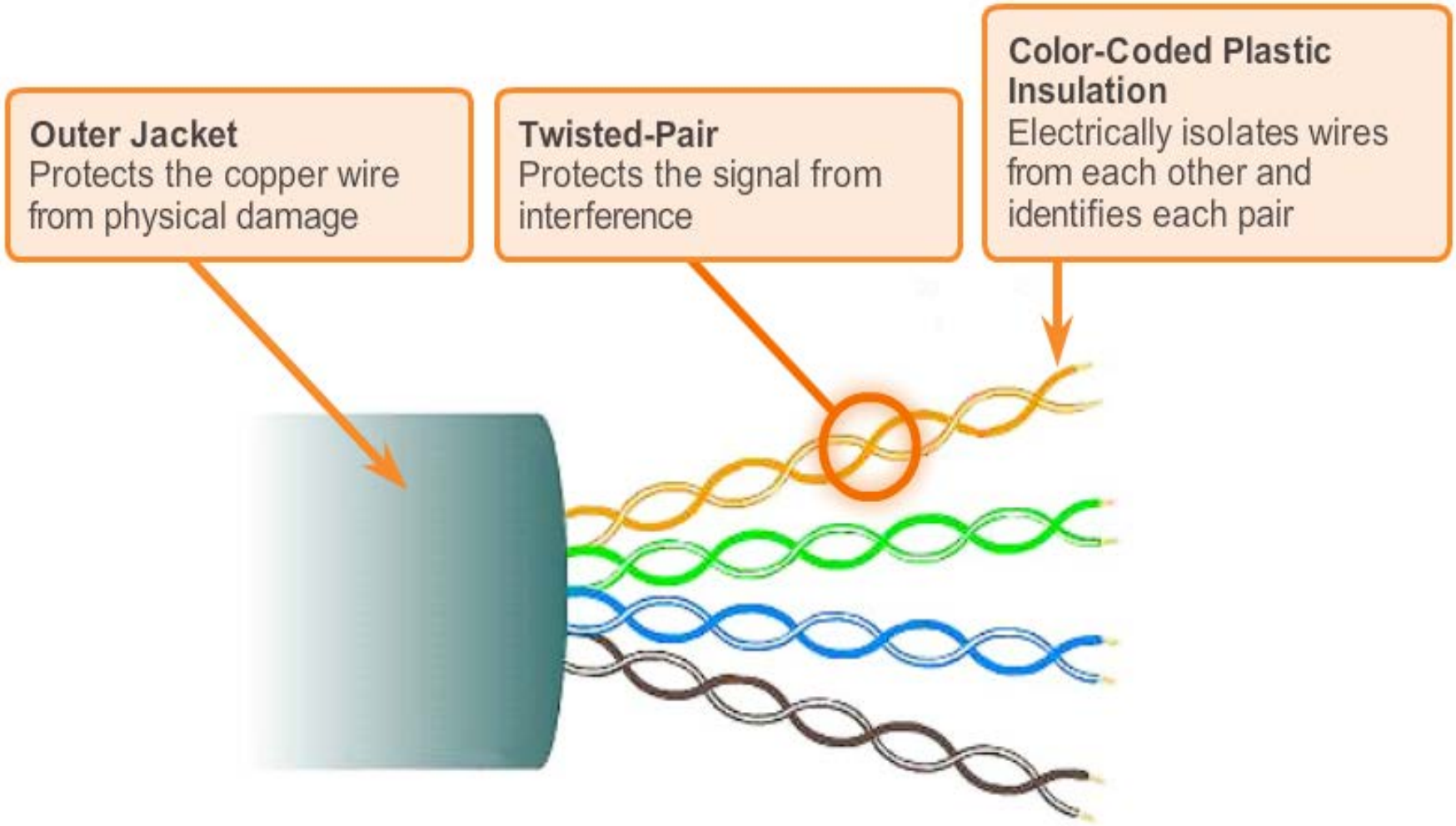
The separation of data and electrical power cabling must comply with safety codes.

Cables must be connected correctly.

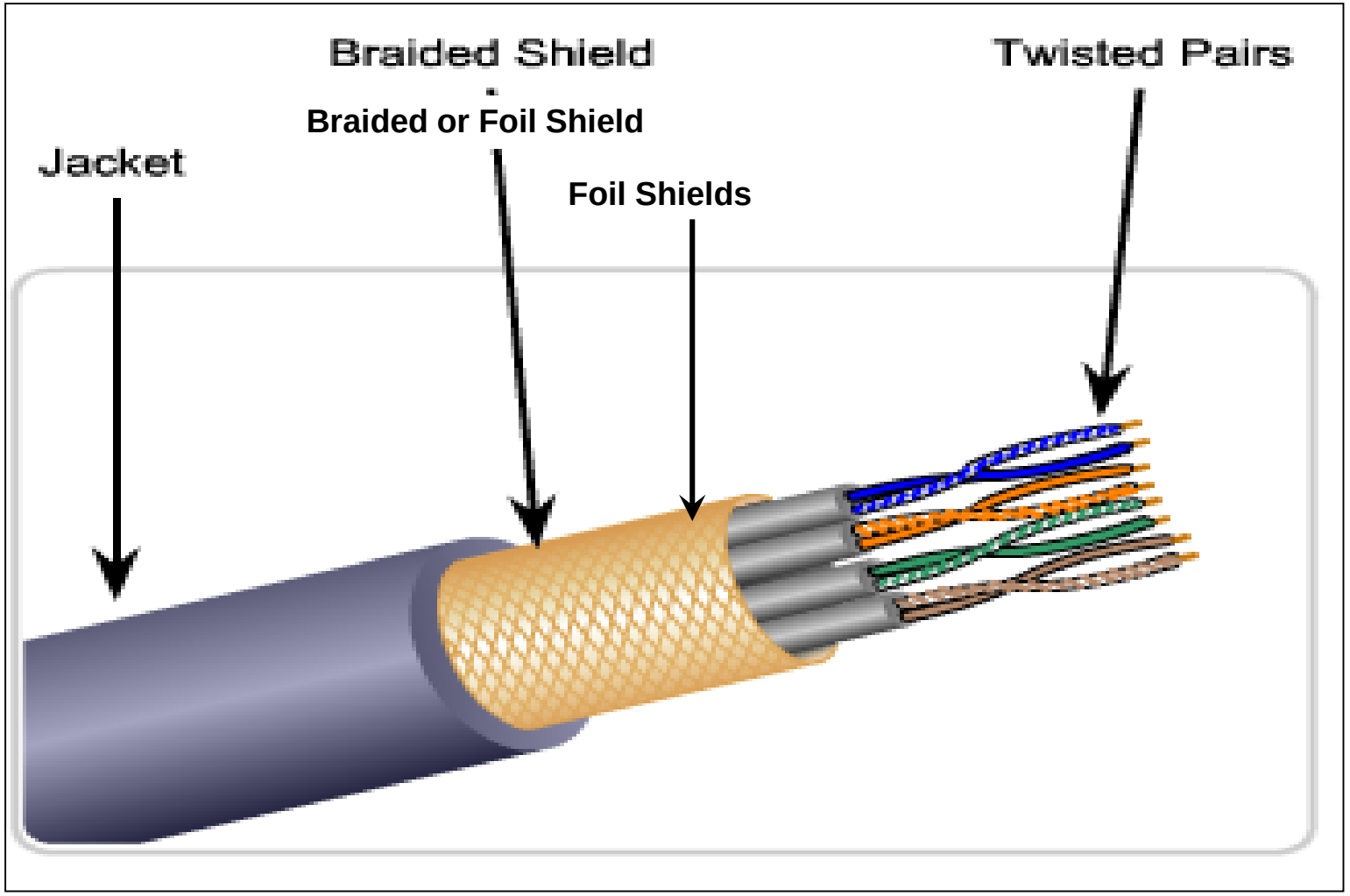
Installations must be inspected for damage.

Equipment must be grounded correctly.

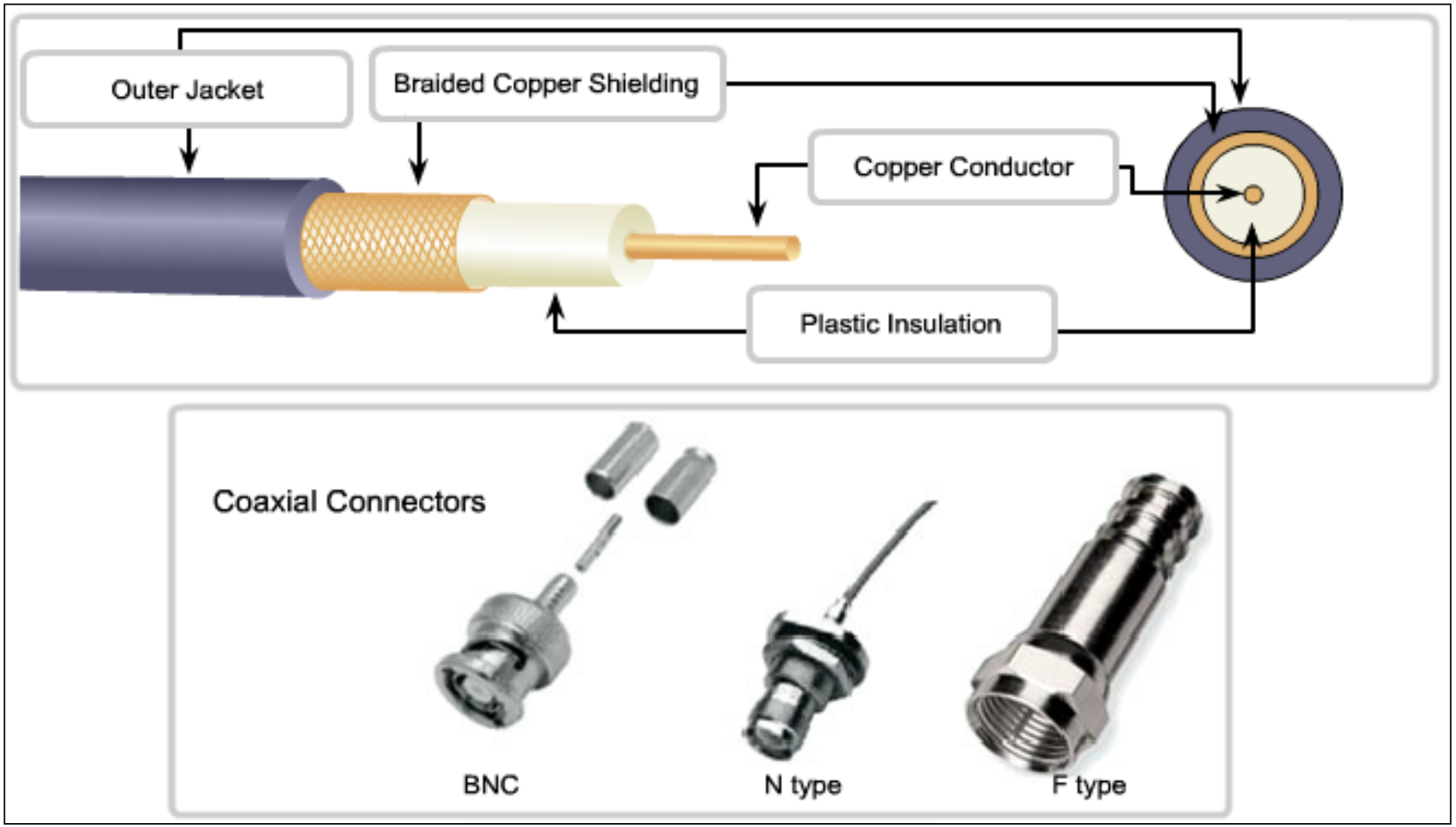
OSI Physical Layer – Network Media
UTP cable



OSI Physical Layer – Network Media
STP Cable



OSI Physical Layer – Network Media
Coaxial Cable



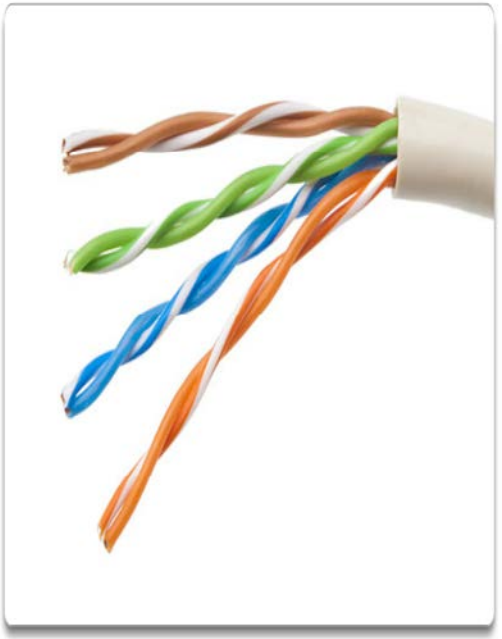
OSI Physical Layer – Network Media Properties of UTP Cabling

UTP cable does not use shielding to counter the effects of EMI and RFI.

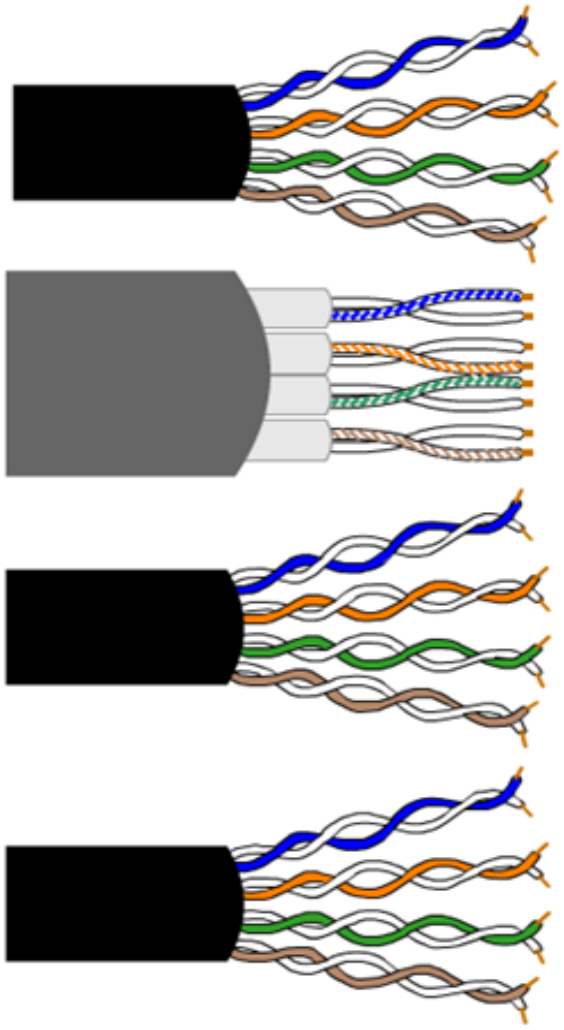
They limit the negative effect of crosstalk by:

- Cancellation
- Varying the number of twists per wire pair

Crosstalk is a disturbance caused by the electric or magnetic fields of one telecommunication signal affecting a signal in an adjacent circuit.
In an telephone circuit, **crosstalk** can result in your hearing part of a voice conversation from another circuit.



OSI Physical Layer – Network Media
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)

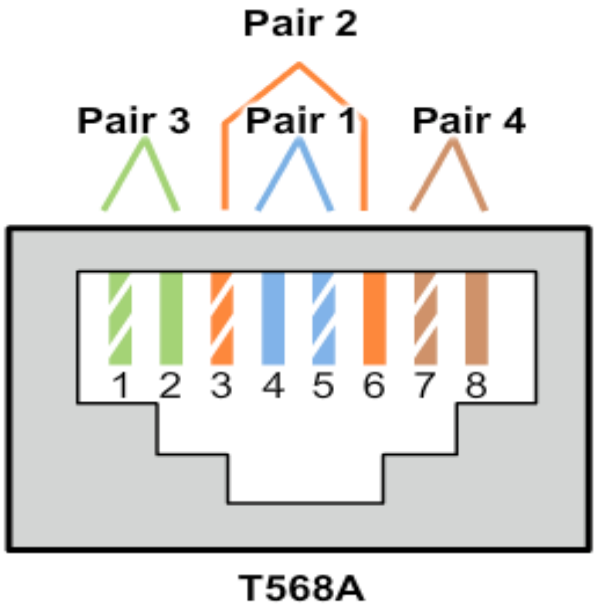
- Used for Data transmission
- Cat 5 supports 100 Mbps and can support 1000 Mbps but it is not recommended
- Cat 5e supports 1000 Mbps

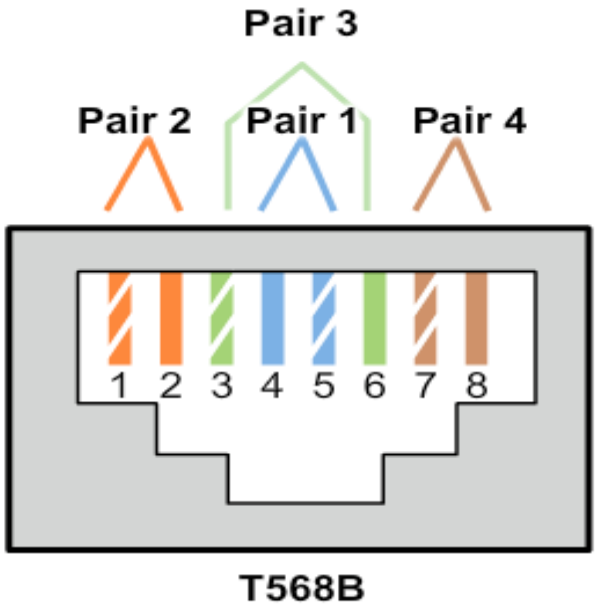
OSI Physical Layer – Network Media
UTP Connectors

RJ-45 UTP Plugs

RJ-45 UTP Socket

OSI Physical Layer – Network Media
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.

OSI Physical Layer – Network Media
Testing UTP Cables

After installation, a UTP cable tester should be used to test for the following parameters:

- Wire map
- Cable length
- Signal loss due to attenuation
- Crosstalk

Attenuation – loss or reduction of signal strength

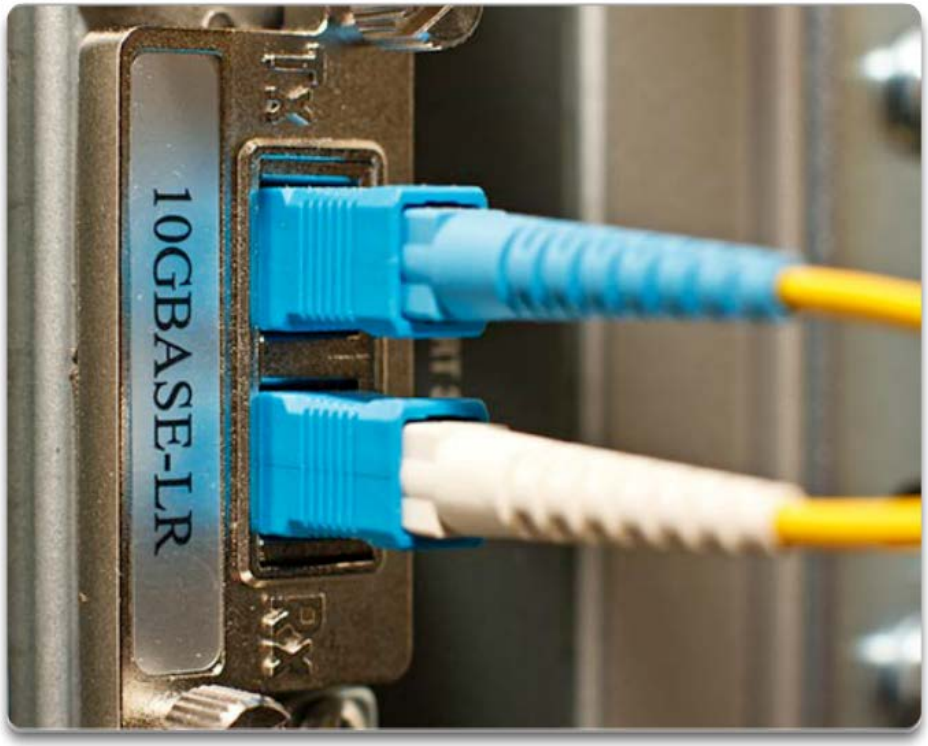
OSI Physical Layer – Network Media
Fiber Optic Cables

- Fiber-optic cables are the second type of media used.
- **Fiber-optic** communication is a method of transmitting information from one place to another by sending pulses of light through an **optical fiber**.
- The light forms an electromagnetic carrier wave that is modulated to carry information.
- Fiber-optic lines are strands of optically pure **glass** as thin as a human hair.
- They can carry digital information over long distances.

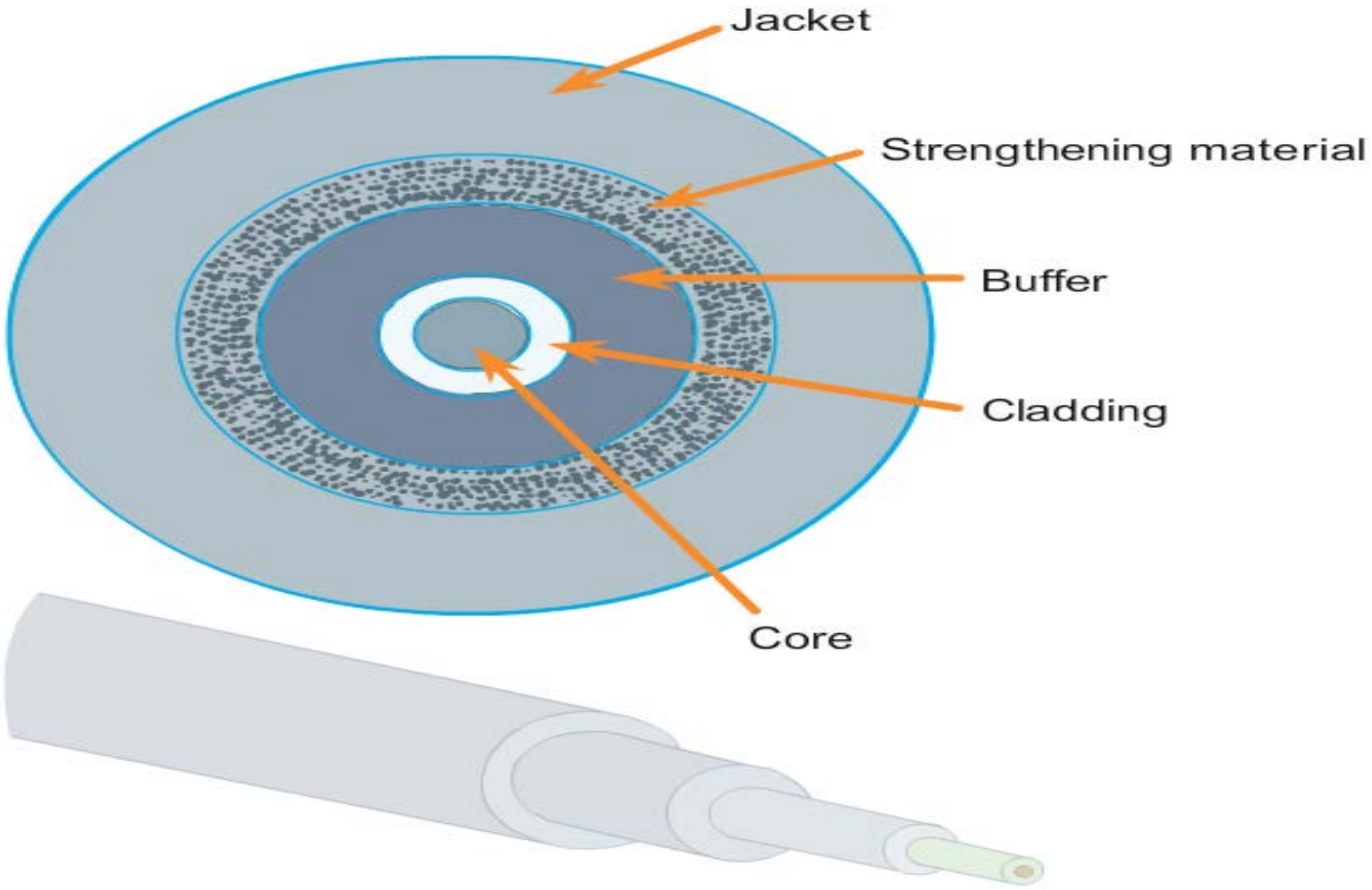
OSI Physical Layer – Network Media
Fiber Optic Cables

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



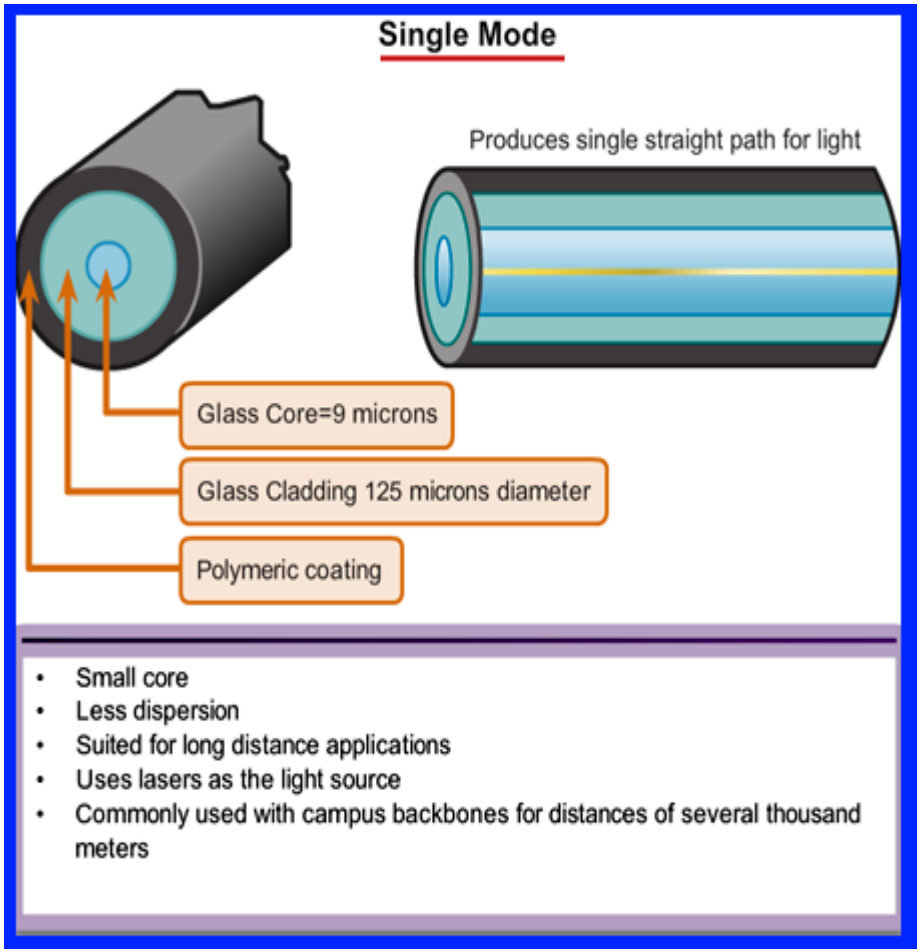
OSI Physical Layer – Network Media
Fiber Media Cable Design

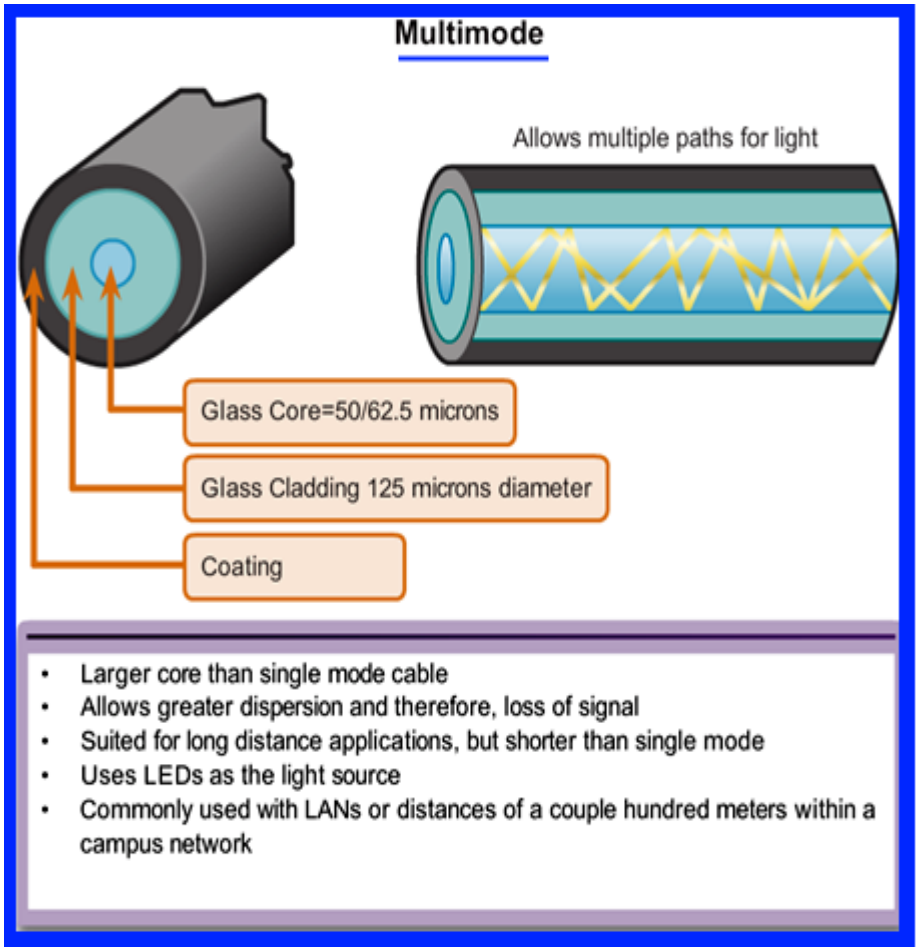


OSI Physical Layer – Network Media
Fiber Cable

There are two types of fiber cable:

- Single-mode
- Multimode





OSI Physical Layer – Network Media
Network Fiber Connectors

Cables need connectors for them to be fixed to a device or access point.

The 4 types of fiber connectors are:

ST Connectors

SC Connectors

LC Connector

Duplex Multimode LC Connectors

OSI Physical Layer – Network Media Testing Fiber Cables

The cables must be tested to be in working order before being used. The device for testing fiber cables is known as the Optical Time Domain Reflectometer.

Optical Time Domain Reflectometer (OTDR)

OSI Physical Layer – Network Media Fiber versus Copper

Fiber Optic is superior to copper in all areas.

Implementation Issues (Characteristics)	Copper Media	Fibre Optic
Bandwidth Supported	10 Mbps – 10 Gbps	10 Mbps – 100 Gbps
Effective distance for signal	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

OSI Physical Layer – Network Media Properties of Wireless Media

Wireless media have some areas of concern, including:

- Coverage area – cannot cover some places
- Interference – from electrical signals
- Security – open to hackers

OSI Physical Layer – Network Media
Types of Wireless Media

	• 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

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

OSI Physical Layer – Network Media
802.11 Wi-Fi Standards

Standard	Maximum Speed	Frequency	Backwards Compatible
802.11a	54 Mbps	5 GHz	No
802.11b	11 Mbps	2.4 GHz	No
802.11g	54 Mbps	2.4 GHz	802.11b
802.11n	600 Mbps	2.4 GHz or 5 GHz	802.11b/g
802.11ac	1.3 Gbps (1300 Mbps)	2.4 GHz and 5.5 GHz	802.11b/g/n
802.11ad	7 Gbps (7000 Mbps)	2.4 GHz, 5 GHz and 60 GHz	802.11b/g/n/ac

END OF CHAPTER 4A