Chapter 8

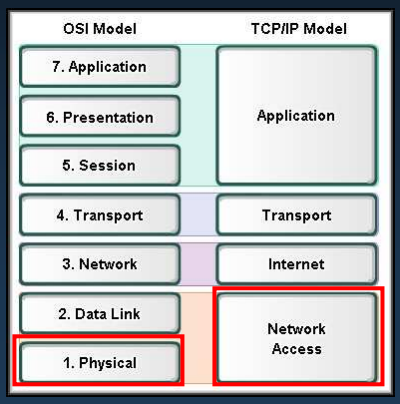
OSI Physical Layer

Note for Instructors

- These presentations are the result of a collaboration among the instructors at St. Clair College in Windsor, Ontario.
- Thanks must go out to Rick Graziani of Cabrillo College. His material and additional information was used as a reference in their creation.
- If anyone finds any errors or omissions, please let me know at:
  - tdame@stclaircollege.ca.

OSI Physical Layer

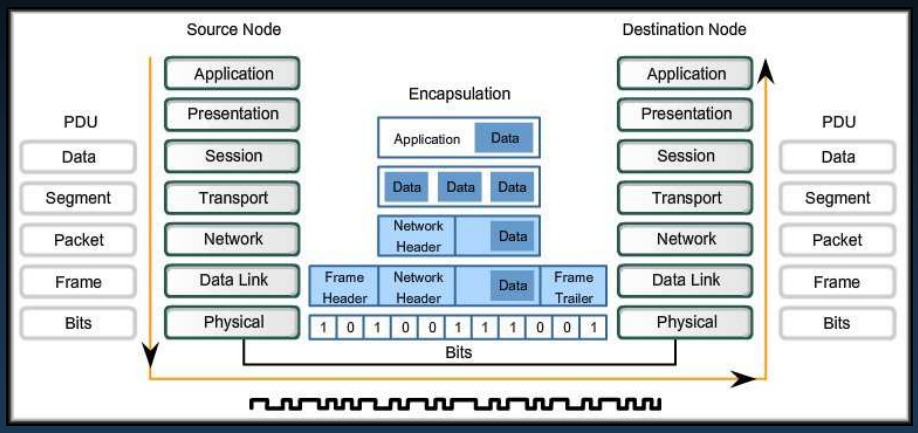
Communication Signals



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



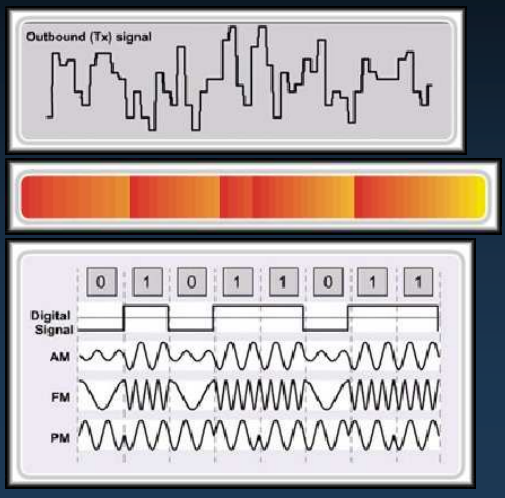
Physical Layer Operation

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

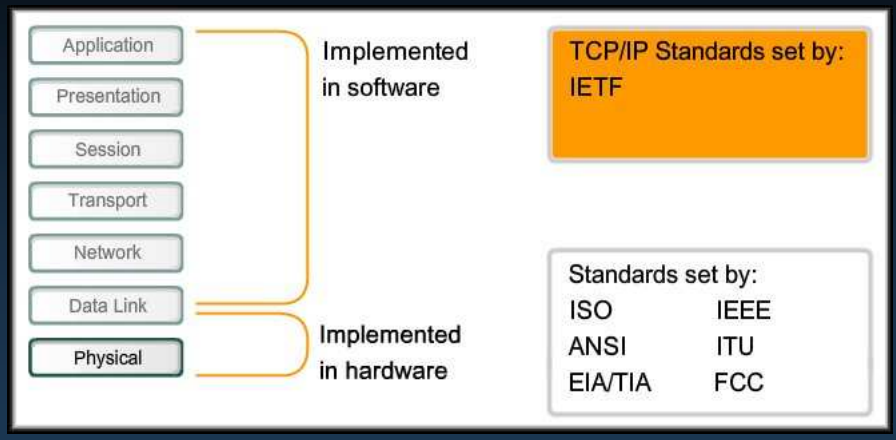
Copper Cable

Fiber-optic

Wireless



Physical Layer Standards



Physical Layer Standards

- *International Standards Organization* (ISO):
  - A network of national standards institutes from 140 countries.
  - Released the OSI reference model in 1984.

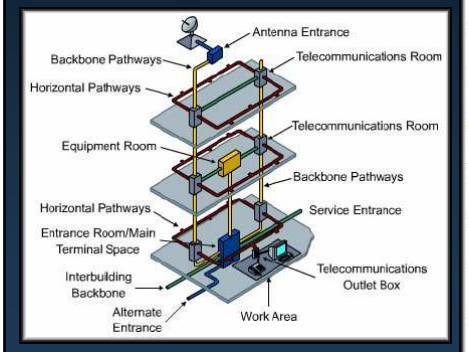
Physical Layer Standards

- *The Institute of Electrical and Electronic Engineers* (IEEE):
  - A professional organization that defines the standards for many LAN protocols.

Standard	Use	Standard	Use
802.1	Network Management	802.9	VoIP
802.2	Logical Link Control	802.10	Network Security
802.3	Ethernet	802.11	Wireless
802.4	Token Bus	802.12	Demand Priority Access
802.5	Token Ring	802.13	Unused
802.6	MANs	802.14	Cable Modem
802.7	Broadband	802.15	WPAN
802.8	Fiber Optic	802.16	Broadband Wireless

Physical Layer Standards

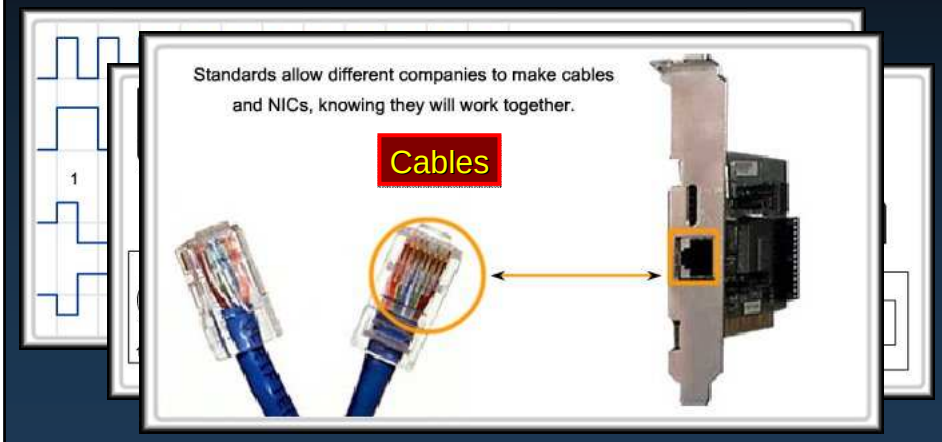
- *Telecommunications Industry Association* (TIA) *and Electronic Industries Association* (EIA):
  - A standards organization covering structured voice and data wiring for LANs.



TIA/EIA-568-B.1	Commercial Building Telecommunications Cabling Standard – General Requirements
TIA/EIA-568-B.2	Balanced Twisted Pair Cabling Components
TIA/EIA-568-B.3	Optical fiber Cabling Components
TIA/EIA-568-B	Cabling Standards
TIA/EIA-569-A	Commercial Building Standard for Telecommunications Pathways and Spaces
TIA/EIA-570-A	Residential and Light Commercial Telecommunications Wiring Standard
TIA/EIA-606	Administration Standard for the Telecommunications Infrastructure of Commercial Buildings
TIA/EIA-607	Commercial Building Grounding and Bonding Requirements for Telecommunications

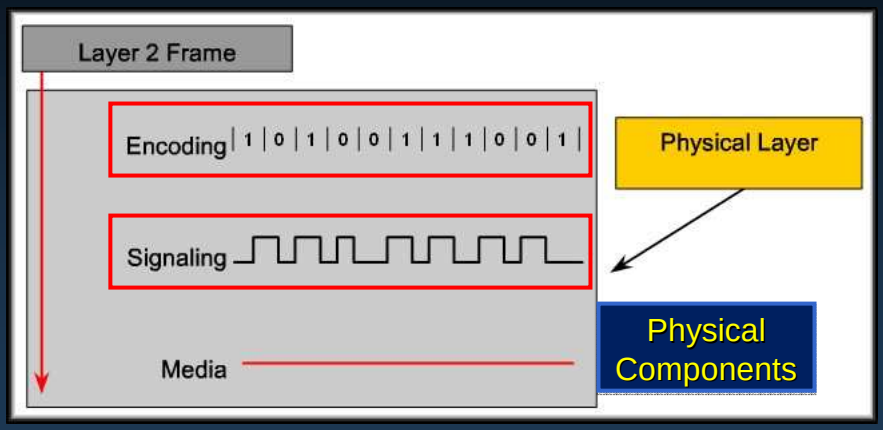
Physical Layer Standards

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



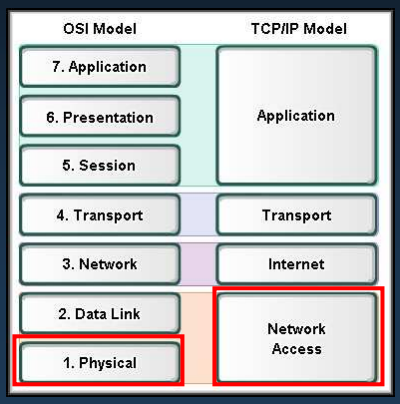
Physical Layer Fundamental Principles

- Three fundamental functions:



OSI Physical Layer

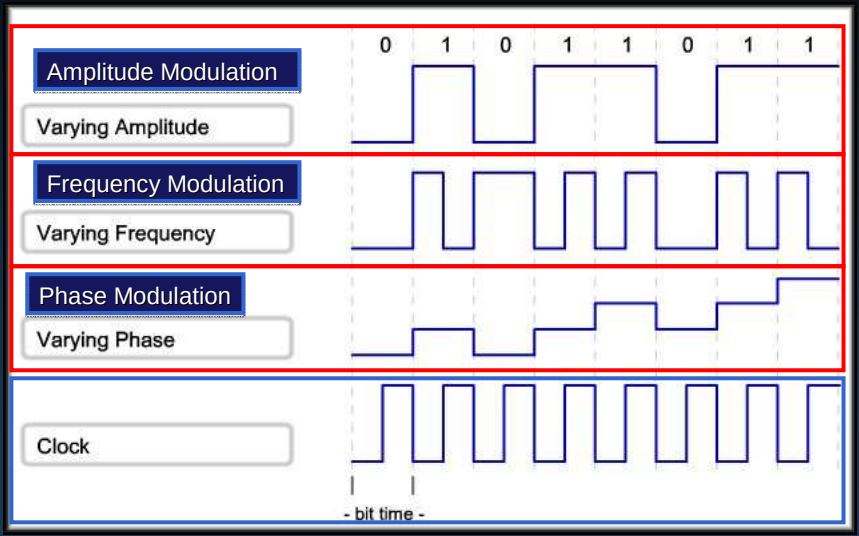
Physical Signaling and Encoding: Representing Bits



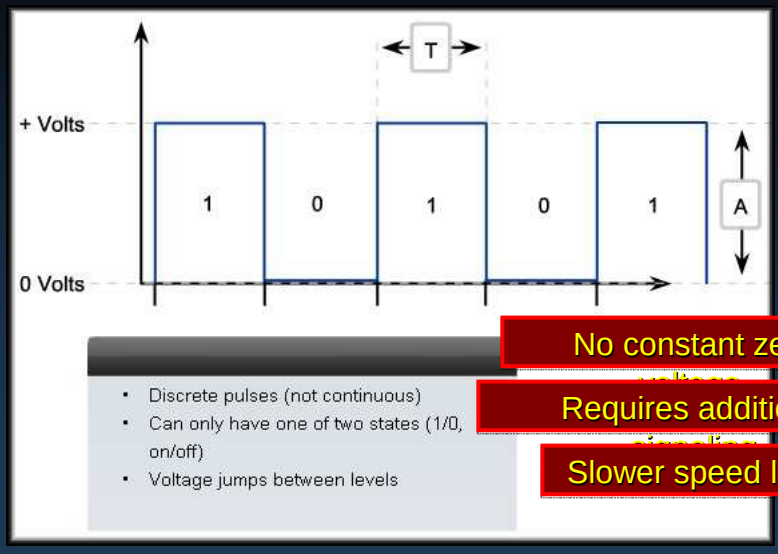
Signaling Bits for the Media

- *Eventually, all communication from the human network becomes binary digits, which are transported individually across the physical media.*
  - Transmission of the occurs as a stream of bits sent one at a time.
  - Each of the bits in the frame represented as a signal.
  - Each signal has a specific amount of time to occupy the media.
    - This is referred to as its bit time.

Signaling Bits for the Media



Example: Nonreturn to Zero (NRZ)



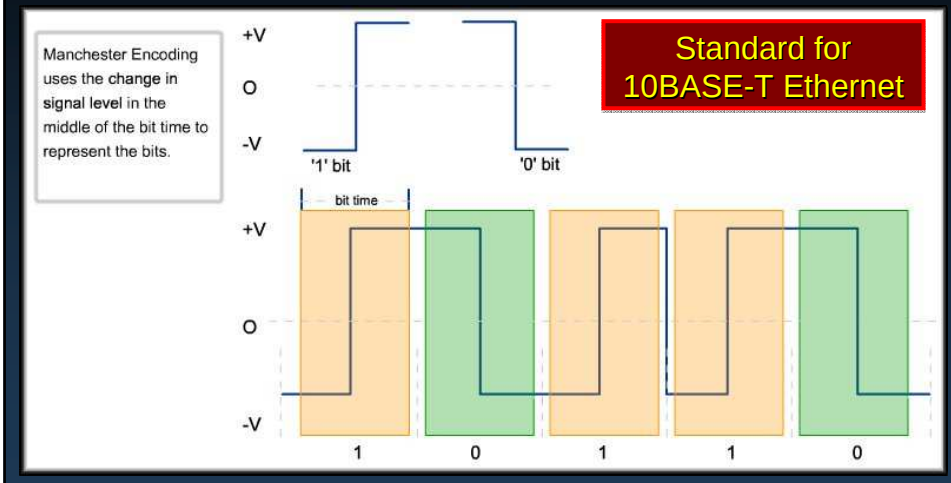
- Discrete pulses (not continuous)
- Can only have one of two states (1/0, on/off)
- Voltage jumps between levels

No constant zero

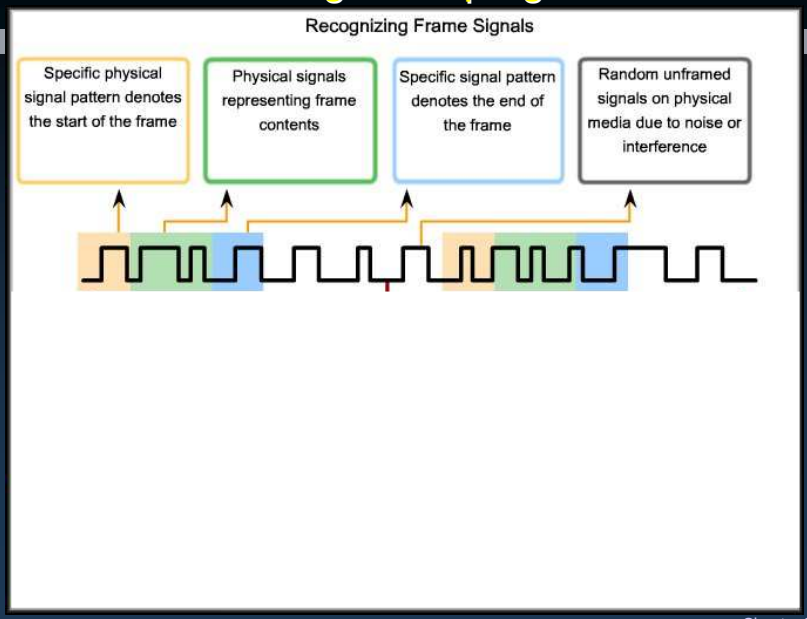
Requires additional

Slower speed lines.

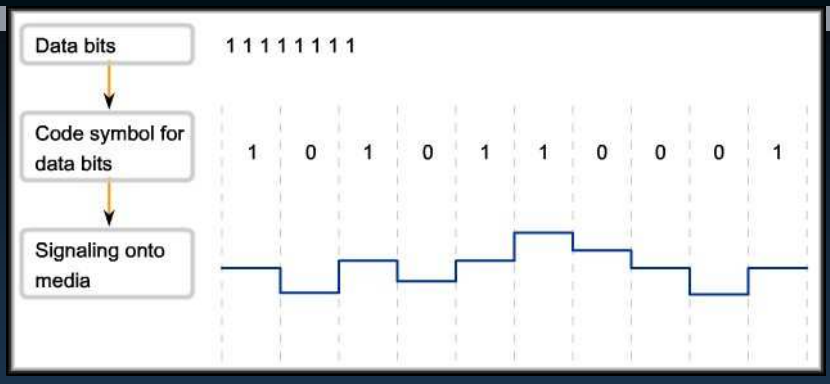
Example: Manchester Encoding



Encoding: Grouping Bits

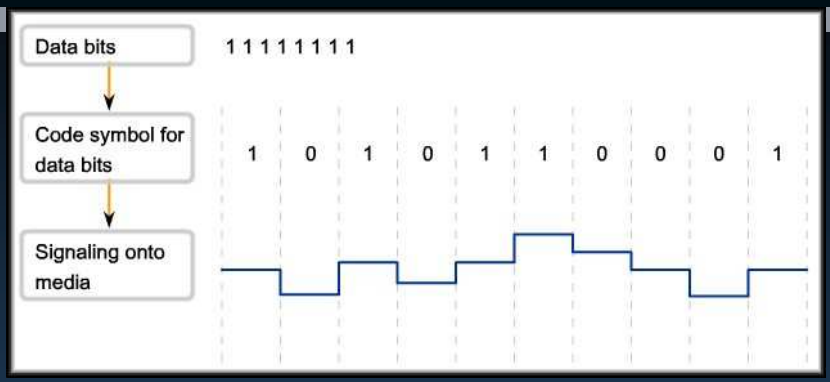


Encoding: Grouping Bits (Code Groups)



- Code Groups:
  - Technique used for higher speed LAN technologies.
  - A consecutive sequence of code bits that are interpreted and mapped as data bit patterns.

Encoding: Grouping Bits (Code Groups)



- Increased overhead but……
  - Reduces bit level errors.
  - Limits the energy transmitted on to the media.
  - Helps distinguish data and control bits.
  - Better media error detection.

Example: 4B/5B Code Group

4B/5B Code Symbols

Data Codes

4B Code	5B Symbol
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

Control and Invalid Codes

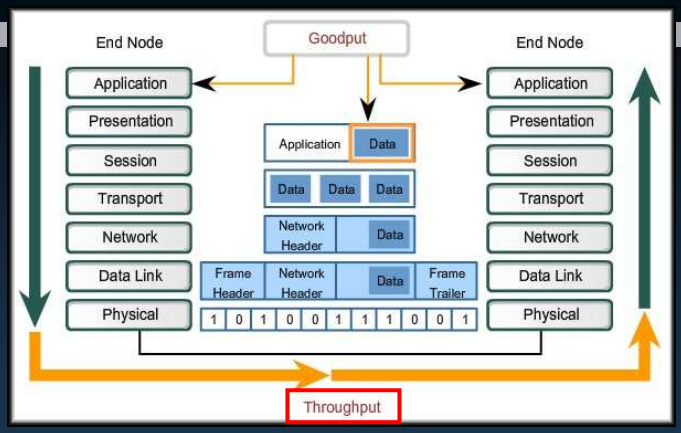
4B Code	5B Symbol
idle	11111
start of stream	11000
start of stream	10001
end of stream	01101
end of stream	00111
transmit error	00111
invalid	00000
invalid	00001
invalid	00010
invalid	00011
invalid	00100
invalid	00101
invalid	00110
invalid	01000
invalid	10000
invalid	11001

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

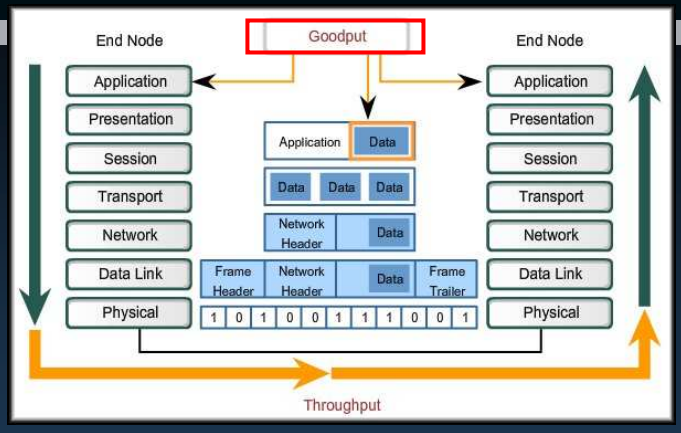
- Bandwidth (Theoretical):
  - The capacity of a medium to carry data in a given amount of time.
  - Takes into account the physical properties of the medium and the signaling method.

Data Carrying Capacity



- Throughput (Practical):
  - Transfer rate of data over the medium.
  - Factors affecting throughput:
    - Amount and type of traffic, number of devices.

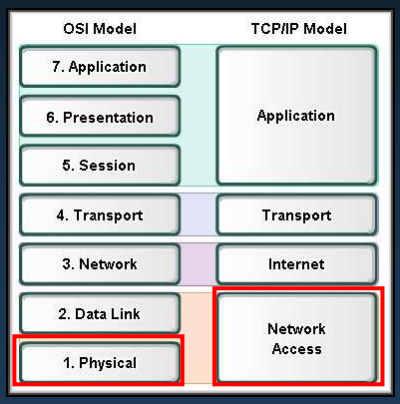
Data Carrying Capacity



- Goodput (Qualitative):
  - Transfer rate of actual usable data bits.
  - Throughput less the data protocol overhead, error corrections and retransmissions.

OSI Physical Layer

Physical Media: Connecting Communication

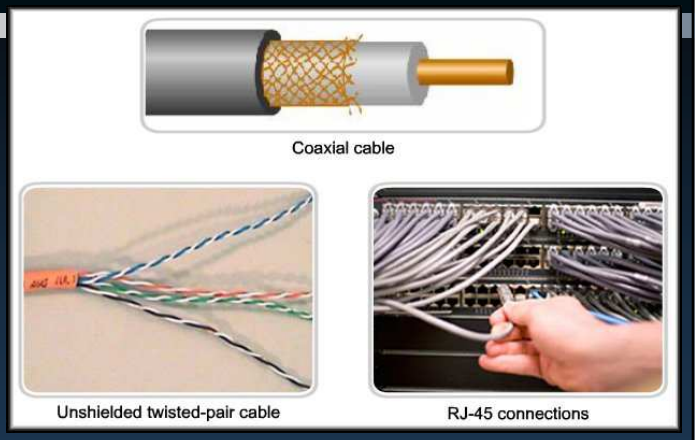


Types of Physical Media

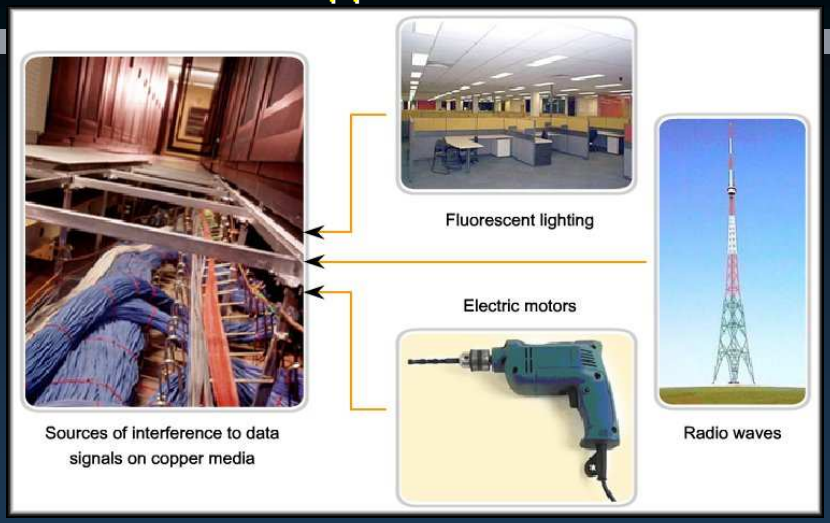
Specification	Media	Maximum Segment Length	Connector
10BASE-T	CAT 3,4 or 5 UTP (4 pair)	100m	RJ-45
100BASE-TX	CAT 5 UTP (2 pair)	100m	RJ-45
100BASE-FX	62.5/125 multimode fiber	2km	
1000BASE-CX	STP	25m	RJ-45
1000BASE-T	CAT 5 UTP (4 pair)	100m	RJ-45
1000BASE-SX	62.5/50 multimode fiber	62.5 – 275m 50 – 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



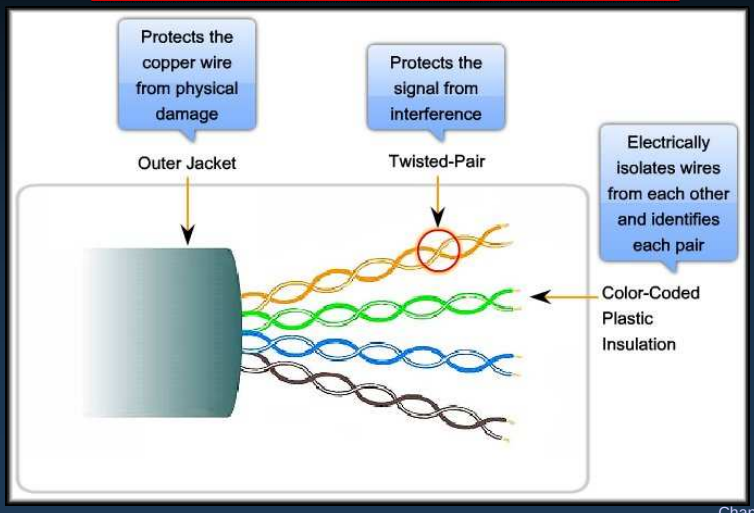
Copper Media



- Interference:
  - Data travels as electrical pulses.

Copper Media

Unshielded Twisted-Pair (UTP) Cable

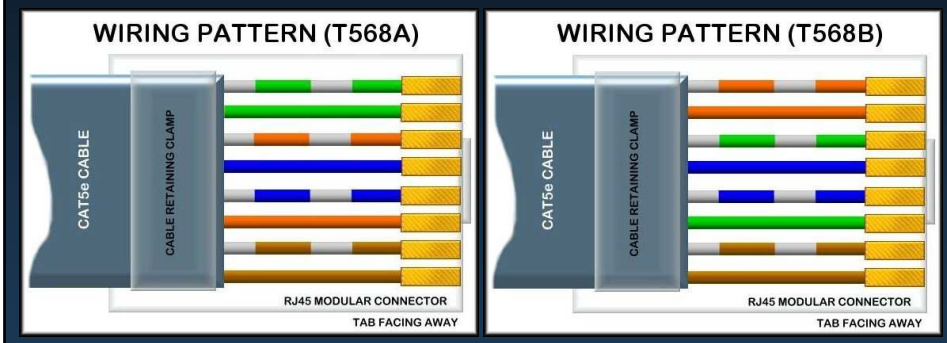


Copper Media

- 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 – recommended standard for gigabit

Copper Media

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

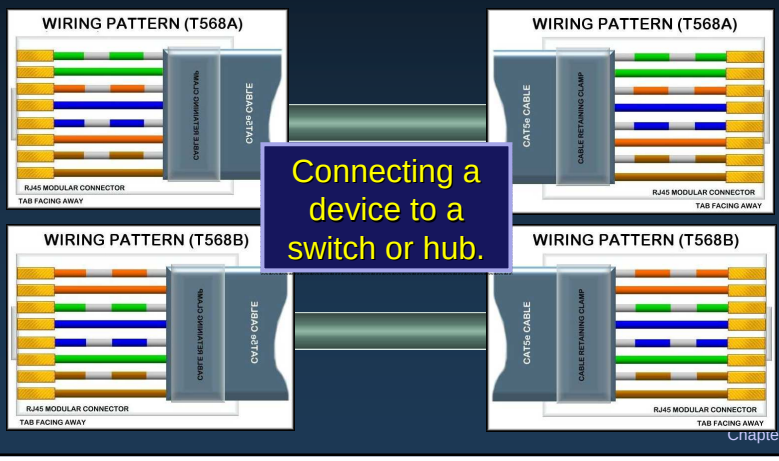


Copper Media

- UTP Cable Types:
  - Different situations may require UTP cables to be wired according to different wiring patterns:
    - Ethernet Straight-through
    - Ethernet Crossover
    - Rollover

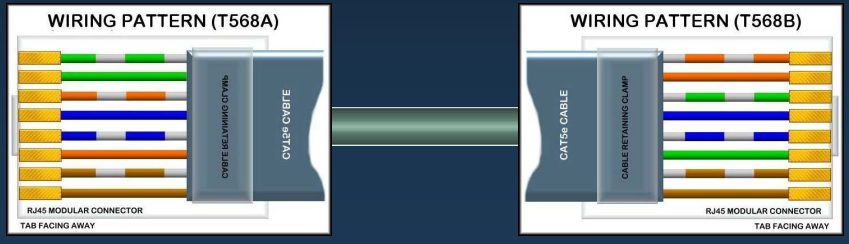
Copper Media

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



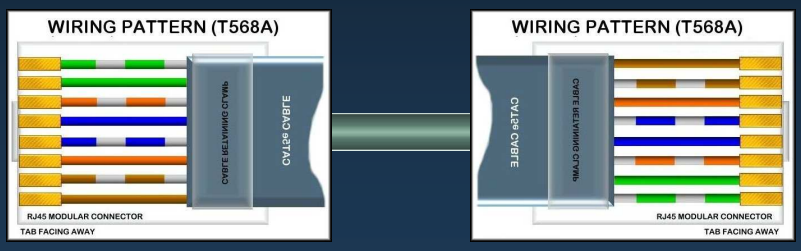
Copper Media

- 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



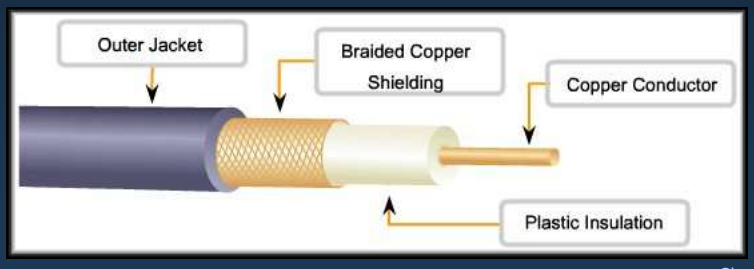
Copper Media

- 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.



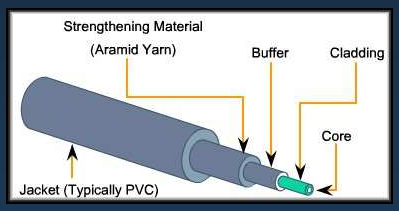
Copper Media

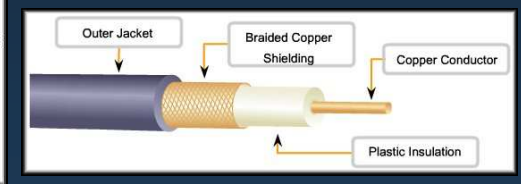
- Other Copper Cable Types:
  - Coaxial Cable:
    - Used in wireless and cable access technologies.
      - Attach antennas to wireless devices.
      - Transmitting television channels.
      - Can run longer distances than STP or UTP.



Copper Media

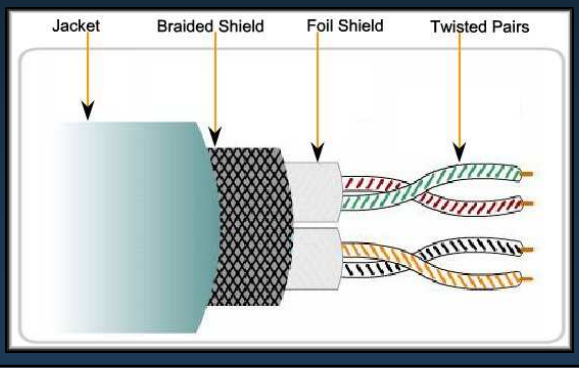
- Other Copper Cable Types:
  - Hybrid Fiber-Coax (HFC):
    - Cable structure used to provide two way communication over a coaxial cable (i.e. cable connection to the Internet)
      - Coaxial at the destination but multi-fiber optical cable to the provider.





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.

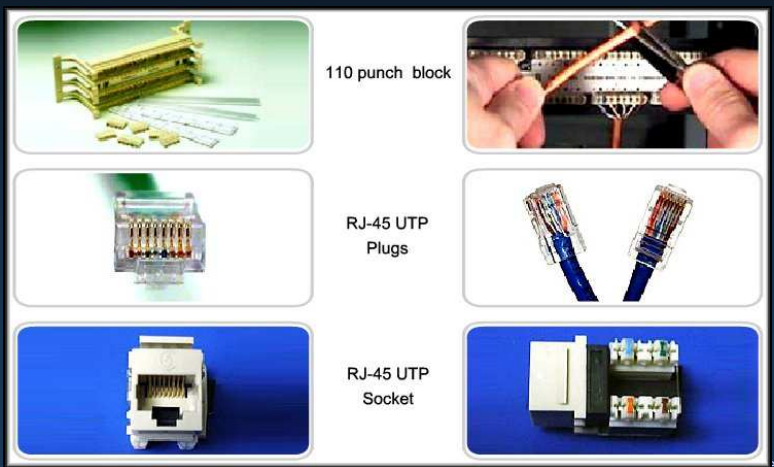
Cables must be connected correctly.

Installations must be inspected for damage.

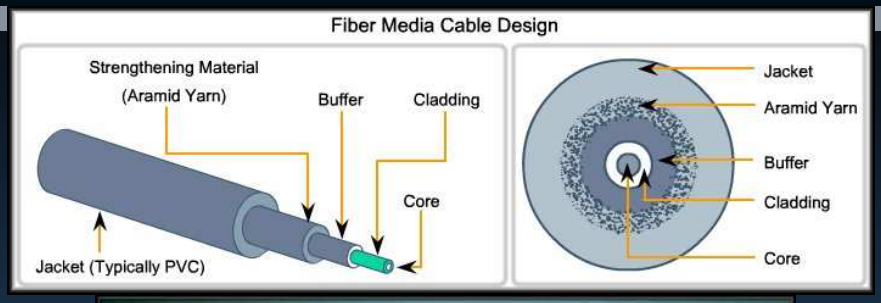
Equipment must be grounded correctly.

Copper Media Connectors

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

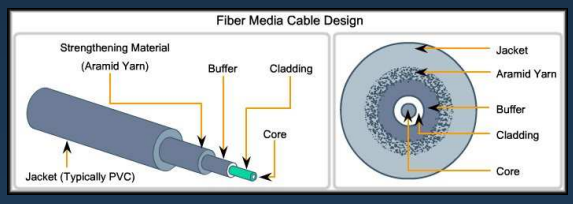


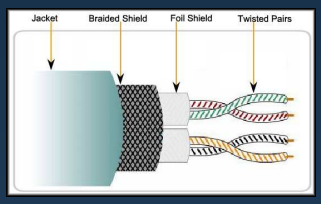
Fiber Media



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).

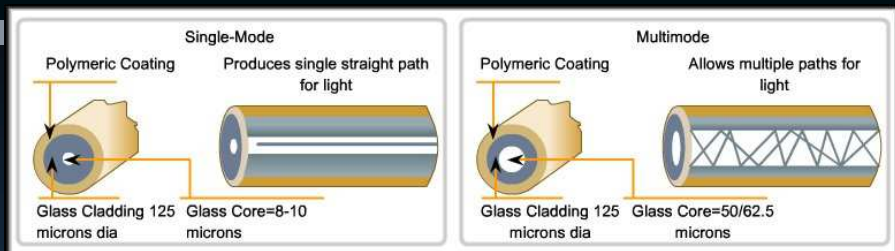




Fiber Media

- 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.

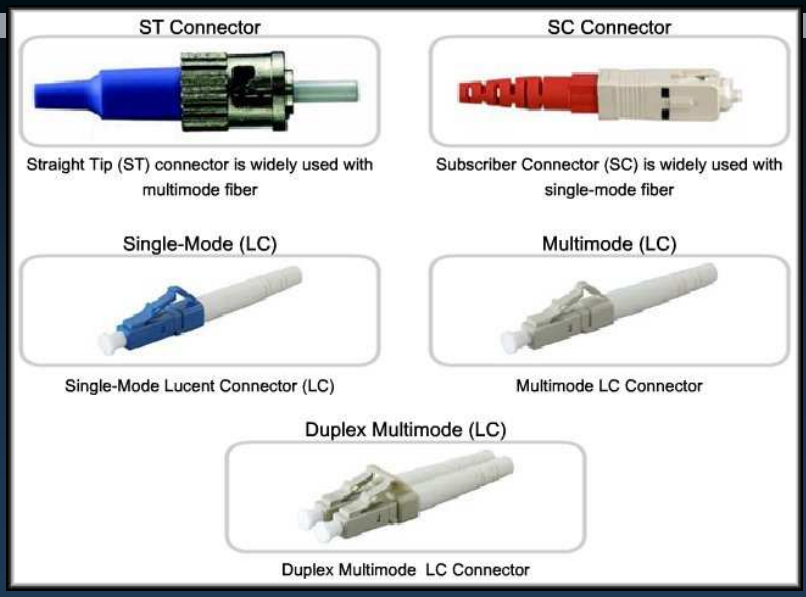
Fiber Media



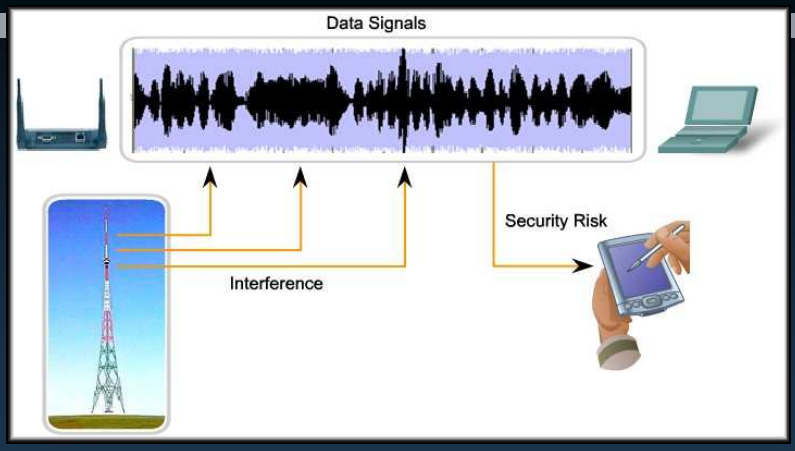
- Small Core
- Less Despersion
- Suited for long distance applications (up to 100 km, 62,14 mi.)
- Uses lasers as the light source often within campus backbones for distance of several thousand meters

- 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



Wireless Media



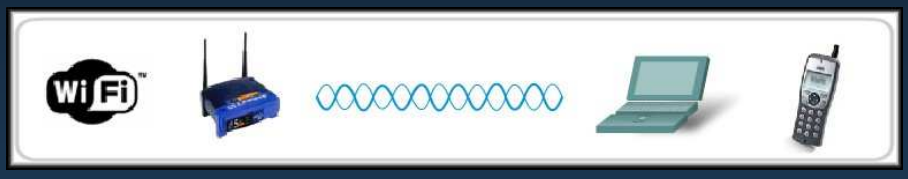
- Wireless media carry electromagnetic signals at radio and microwave frequencies that represent the binary digits of data communications.

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.