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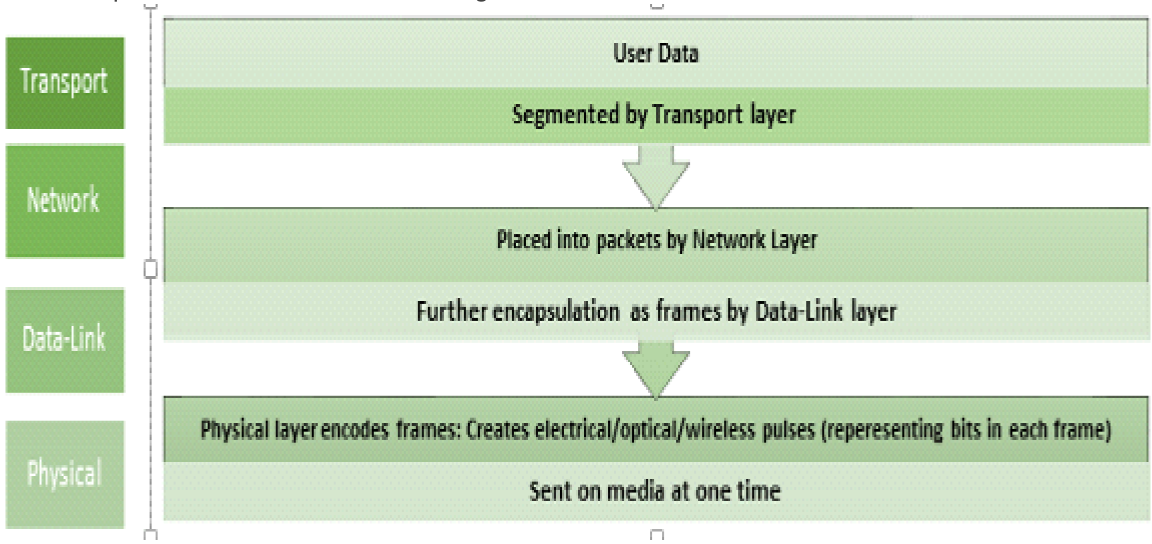
Thursday, January 24, 2019 10:49 PM

THE PHYSICAL LAYER

Physical: The way bits are transported: Makes up a link layer frame across media
- Accepts frames/encodes them as signals transmitted onto media

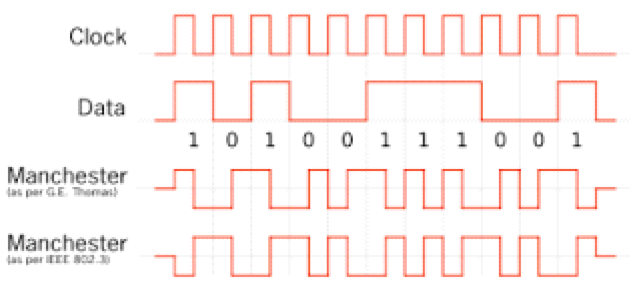


3 media forms: Governed by: **IETF/ISO/IEEE/TIA/EIA/ITU/ANSI**
1. **Copper:** Electrical
2. **Fiber:** Light
3. **Wireless:** Radio transmission

The physical layer standards address 3 areas:
1. **Components**
2. **Encoding**
3. **Signaling**

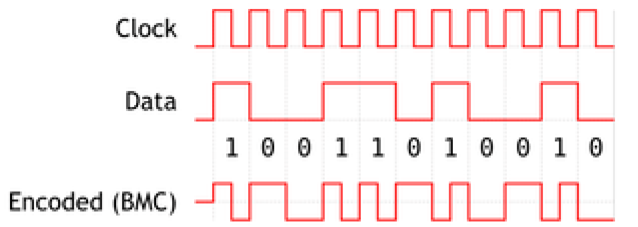
Components	Hardware/connectors (transmits signals to represent bits)
Encoding	Conversion of streaming bits into predefined codes
Code	Groupings of bits: Provides patterns recognized by sender/receiver
Encoding	Pattern of voltage/current used to represent bits: 0 | 1

Manchester encoding: Used in versions of Ethernet/RFID/NFC



0 == High-to-low voltage transition
1 == Low-to-high voltage transition

NRZ: Non-Return to Zero: Encoded data has 0 and 1 but no neutral or rest position



0 == One voltage level on media
1 == Different voltage

Signal transmission done one of 2 ways:

1. **Asynchronous:** Signals transmitted without an associated clock signal
   - **Time spacing between characters/blocks can be arbitrary**
   - **Frames require START/STOP indicator flags**
2. **Synchronous:** Signals sent along a clock signal that occurs at bit time
   - **Bit time: Evenly spaced duration**

Modulation: Process which characteristics of 1 wave (signal) modifies another (carrier)
Modulation techniques widely used in transmitting data:

FM	**Frequency Modulation:** Carrier frequency varies in accordance w/signal
AM	**Amplitude Modulation:** Amplitude varies in accordance with signal
PCM	**Pulse-Coded Modulation:** • Analog signals (voice) converted to digital by sampling amplitude/expressing diff amplitudes as bin nums • Sampling rate must be at least 2x highest frequency

Nature of signals representing bits depends on signaling method:

- Some may use one attribute of signaling to represent a 0: Another to represent 1

Bandwidth: The capacity of a medium to carry data:

- Measures data flow from one place to another in a given time

Bandwidth determined partially by:

1. Media properties
2. Tech chosen for signaling/detecting signals

Throughput/Goodput: Measures transfer of bits across media in given time

Factors that influence throughput: <u>Amount of traffic</u> || <u>Type of traffic</u>

- Latency created by num of devices encountered bet source/dest
- Throughput can't be faster than slowest link from source/dest
- Even if segments have high bandwidth:
  - Creates bottleneck via 1 segment in path with low throughput

Goodput: Measures usable data transferred over given period of time
Throughput: Overhead (established sessions/acknowledgements, encapsulations)
Copper Media: Low resistance to current (limited by distance/interference)

- Data transmitted as electrical pulses can successfully decode to match sent signals

Attenuation: The longer a signal travels, the more it deteriorates
Interference from 2 sources:

1. **EMI: Electromagnetic Interference**
2. **RFI: Radio Frequency Interference**

EMI/RFI: Distorts/corrupts signals carried by copper

- Radio waves/electromagnetic devices/fluorescent lights etc..

Crosstalk: Disturbance caused by electric/magnetic fields of a signal on one wire to another

- Current/circular magnetic fields created around wires that can be picked up by other wires

Countering:

EMI/RFI	Copper cables: Wrapped in metallic shielding that require groundings
Crosstalk	Copper cables: Opposing circuit wire pairs twisted together (cancels)

Electronic noise reduction:

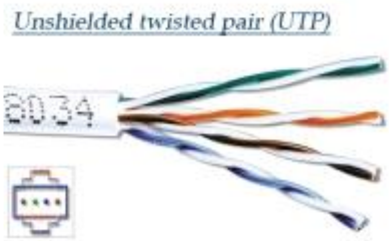
- Cable/category most suited to network environment
- Design infrastructure to avoid potential sources of interference
- Use cabling techniques that include proper handling/termination

Copper Media:

- Interconnects nodes on LAN/devices (switches/routers/access points)
- Each type/device has requirements stipulated by physical standards
- A single physical connector may be used for many types of connections

UTP: Unshielded Twisted Pair	**STP: Shielded twisted pair**	**Coaxial**

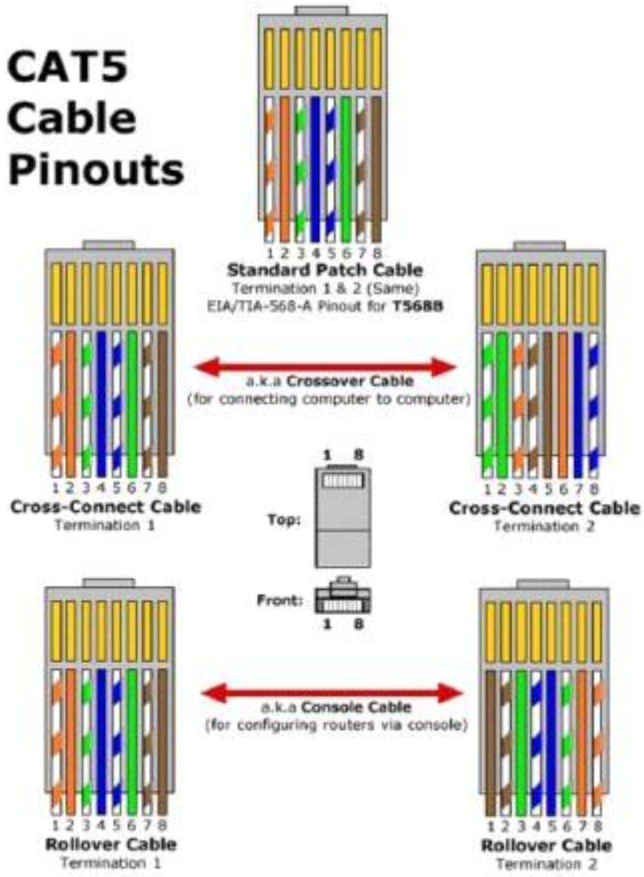
UTP Unshielded Twisted-Pair Cable:

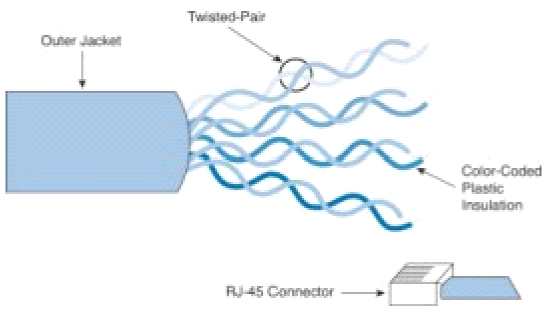


- Terminated with ISO 8877 RJ-45's
- Interconnects network hosts with intermediate devices (switches/routers)
- 4 pairs of color-coded wires twisted together/encased in plastic sheath
- Twisting wires helps protect against signal interference
- 22 or 24 gauge copper wire
- External diameter of approximately .43cm or .17in

Color coding:

Orange-white	Orange	Blue-White	Blue	Green-white	Green	Brown-white	Brown





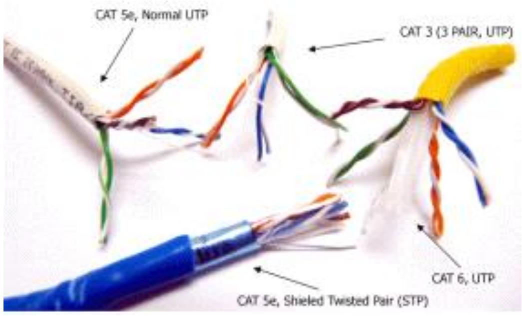
UTP Cabling/Cabling Standards: Crosstalk limited by:

Cancellation	Wires paired in a circuit
Number of twists per pair	<u>Twists of each pair vary:</u> • O/orange-white less than b/white-blue pairs

TIA/EIA-568A stipulates commercial cabling standards for LAN installations
<u>Some elements defined</u>: Types/lengths/connectors/terminations/methods of testing
IEEE: Characteristics of copper cabling/placed into categories based on ability to carry bandwidth

Cat3	• Voice communication/phone lines
Cat5/5e	• Data transmission: 568 standard • Supports: 100 Mbps & 1000 Mbps (Gigabit)
Cat6	• Data transmission: 568 standard • Separator added bet each pair of wires: Allows higher speeds • Supports 1000 Mbps & up to 10 Gbps
Cat7 (ScTP)	• Individual pairs wrapped in shield: 4 pairs wrapped in another shield

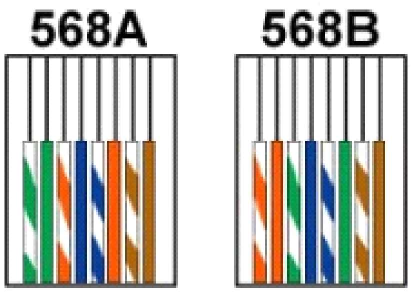
UTP Connectors:



- TIA/EIA 568 standard describes wire colors to pin-outs for Ethernet
- Male component: RJ-45 (socket female)
- Each time cabling terminated: Chance of signal loss/introduction of noise

Cable types for specific wiring conventions:

Straight-Through	• Connect a host to switch/switch to router • Both ends: Either 568A/568B
Crossover	• Connect similar devices: Switch to switch/host to host/router to router • Also used to directly connect host to router • One end: 568A • One end: 568B
Rollover	• Cisco-proprietary cable: Router/switch console port • Pin 1 is Pin 6 on other end



Testing UTP Cables: Wire map/length/sig loss b/c of attenuation/crosstalk

STP Shielded Twisted-Pair Cable:

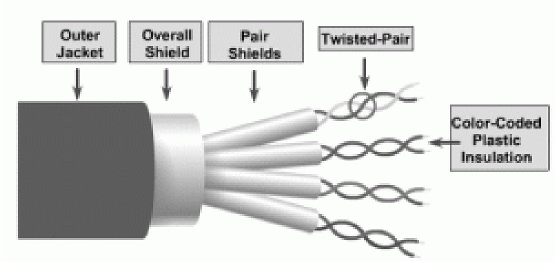
- Better noise protection than UTP: More expensive: Diff to install
- Combines shielding to counter EMI/RFI: Wire twisting to counter crosstalk
- Gain benefit: STP cables terminated with shielded STP data connectors
- Improperly grounded shields: Can act like antennas/pick up unwanted signals

<u>Uses 4 pairs of wires:</u>

- Each wrapped in foil shield: Then wrapped in overall metallic braid/foil
- 10GB: Standard Ethernet has provision for STP

2 most common variations of STP cables:

1. Cable shields entire bundle of wires with foil (no interference)
2. Cable shields entire bundle of wires and individual pairs with foil (no interference)



Coaxial: Derived name because 2 conductors share the same axis

- Copper conductor transmits electronic signals and is surrounded by plastic insulation

Insulating material woven copper braid/metallic foil:

- Acts as second wire in circuit/shield for inner conductor

- Second layer/shield reduces electromagnetic interference
- Different connector types: F//N types/BNC

UTP: Mostly replaced coax in modern Ethernet installations: Still adapted for:

Wireless	Cables attached to antennas/wireless devices: • RF's between antennas/radio equipment
Cable	Portions of coax/elements replaced w/fiber: Final connections coax • **HFC: Hybrid Fiber Coax:** Combined use of fiber/coax

Copper safety: All types susceptible to fire/electrical hazards
Cable insulation/sheaths: Flammable/produce toxic fumes/conduct electricity in bad ways
Cabling practices to avoid hazards:
1. Maintain separation of data/electrical power
2. Connect cables properly/Inspect for damage
3. Properly ground equipment

Fiber-Optic Cabling
- Flexible/extremely thin transparent strands of glass (silica): Like human hair
- Bits encoded as light impulses
- Cable acts as wave guide to transmit light between 2 ends with minimal loss of signal
- Less attenuation/immunity to EFI/RFI

Fiber-optic cabling now used in 4 industry network types:

Enterprise	Backbone cabling applications/interconnecting infrastructure
FTTH	**Fiber-to-the-home** • Provide networks to connect countries/cities • Networks range from few dozen-thousand kilos • Up to 10Gbps-based systems
Submarine	High-speed/capacity solutions capable of surviving harsh undersea environments

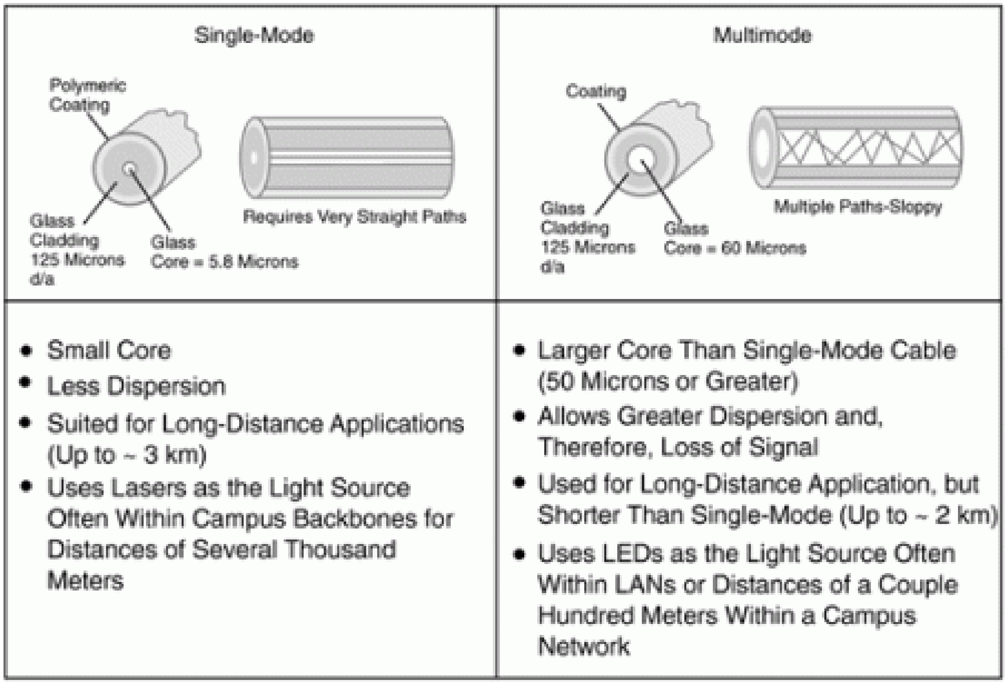
Cable Design:

Core	Pure glass/where light carried
Cladding	Glass that surrounds core: Acts as mirror • Light pulses propagate down core: Cladding reflects pulses • Keeps pulses contained in core: **Total internal reflection**
Jacket	PVC jacket protects core/cladding • Can include strengthening materials/buffer (coating) to protect glass from scratches/moisture

Types of fiber media:
1. Lasers
2. LED: Light Emitting Diodes
- Photodiodes (electronic semiconductors) detect light pulses/convert them to voltages
- These voltages can be reconstructed into data frames

Fiber broadly classified into 2 types: SMF/MMF

Single-Mode	Single light beam down center • Small core: Uses expensive laser tech to send ray of light • Good: Long-distance spanning 100's of kilometers (telephony/ cable TV applications)
Multimode	Reflection of light bouncing inside fiber (many paths/modes) • Larger core: Uses LED emitters to send light pulses • Light from LED enters MMF at different angles • Good for LANS: Can be powered by low cost LEDS • Bandwidth up to 10Gbps over lengths up to 550 meters



Dispersion: Spreading out of a light pulse over time

The major difference between SMF/MMF cabling

- Use of 1 laser in SMF: Less dispersion
- The more dispersion: The greater signal loss/less distance of signal over fiber

Network Fiber Connectors: Connector terminates end of optical fiber

- Main diff among connector types: Dimensions/methods of mechanical coupling

3 most popular network fiber connectors

ST: Straight-tip	Older bayonet style connector: MMF/SMF
SC: Subscriber Connector	Square/standard connector: MMF/SMF • LAN/WAN uses push-pull mechanism for positive insertion
LC: Lucent Connector	Little/local connector: SMF/supports MMF

Other connectors:

- FC: Ferrule Connector
- SMA: Sub Miniature A

Obsolete connectors: Biconic, D4

- Light tends to travel in 1 direction over fiber: 2 fibers required to support full-duplex
- Cables bundle together: Terminate with pair of standard single fiber connectors
- Some connectors accept both transmitting/receiving fibers: **Duplex connector**

Simplex: 1 strand: 1 way communication (telephony)
Full duplex: Both parties communicate with each other simultaneously
Half duplex: Transmission of signals in both directions: Not simultaneously

Common patch cords:

- SC-SC (multimode), LC-LC (single-mode), ST-LC (multimode), SC-ST (single-mode)
- Cables should be protected with plastic cap when not in use
- TIA-598 standard is yellow jackets for SMF and orange (or aqua) for MMF cables

3 most common types of fiber termination/splicing errors:

Misalignment	Fiber-optic media isn't aligned to one another when joined
End Gap	Media doesn't completely touch at the splice/connection
End Finish	Media ends aren't well polished/Dirt is present at the termination

OTDR: Optical Time Domain Reflectometer: Used to test fiber-optic cable segments
Flashlight: Can also be used
Fiber vs. Copper

- Fiber: More expensive over the same distance: Higher capacity
- Different skills/equipment required to terminate/splice
- More careful handling than copper

Wireless Media: Carries electromagnetic signals that represent binary digits of data using radio/microwave frequencies

- Not restricted to conductors or pathways, as copper/fiber

Areas of concern in wireless:

Coverage	Good in open environments/Certain materials can limit coverage
Interference	Susceptible to interference/can be disrupted by common devices
Security	Fairly open/unauthorized users can gain access to transmissions

Types of wireless media (IEEE):

802.11	**WLAN:** Wi-Fi: Contention/nondeterministic system with • **Carrier Sense Multiple Access/Collision Avoidance (CSMA/CA)**
802.15	**WPAN:** Wireless Personal Area Network: BT: • Device pairing processes to communicate over distances 1-100 meters
802.16	**WiMAX:** Worldwide Interoperability for Microwave Access: • Point-to-multipoint topology to provide wireless broadband access

Physical layer specifications applied to areas include:

- Data-to-radio signal encoding
- Frequency/power of transmission
- Signal reception/decoding requirements
- Antenna design/construction

WiFi Standards:

Standard	**Max Speed**	**Frequency**	**Backward Compatibility**
802.11a	54Mbps	5Ghz	No
802.11b	11Mbps	2.4Ghz	No
802.11g	54Mbps	2.4Ghz	802.11b
802.11n	600Mbps	2.4Ghz/5Ghz	802.11a/b/g
802.11ac	1.3Gbps	2.4Ghz/5Ghz	802.11a/b/g/n
802.11ad	7Gbps	2.4Ghz/5Ghz/60Ghz	802.11a/b/g/n/ac