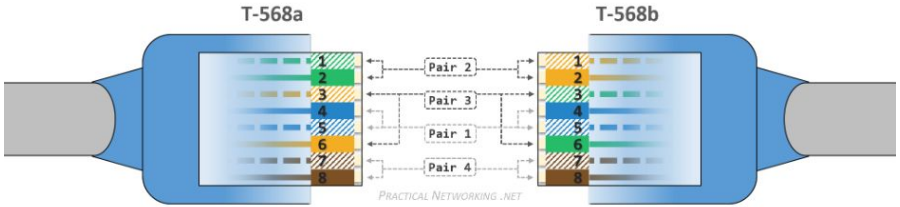
Networks and Internet

How do computers “talk” to each other?

- Need two main things:
  - Connection
    - Computers don’t have vocal cords or ears like humans, they need to be able to send signals to each other in another way
    - also, want to make it as fast as possible
  - Protocol
    - Like humans, computers can transmit the same signals (i.e., vocal sounds for humans), but they must agree on a language or they won’t be able to understand each other

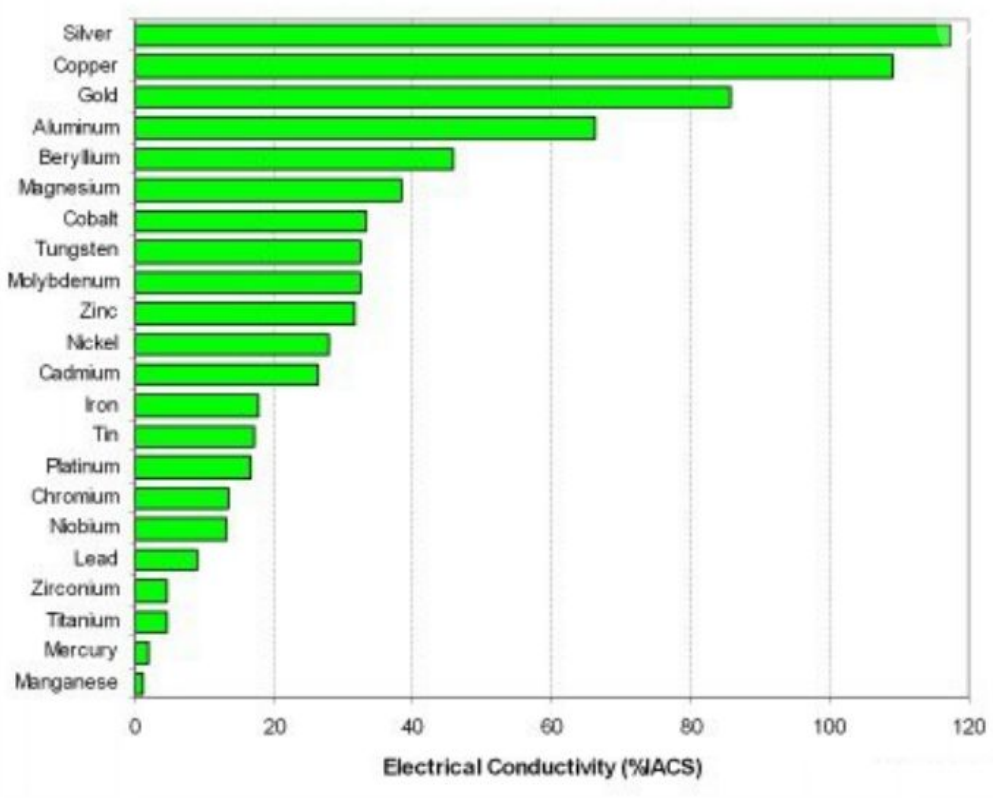
Wired Connections

- “Ethernet” describes the standards for wired connections
  - Example, Twisted Pair Copper Cable Specification:

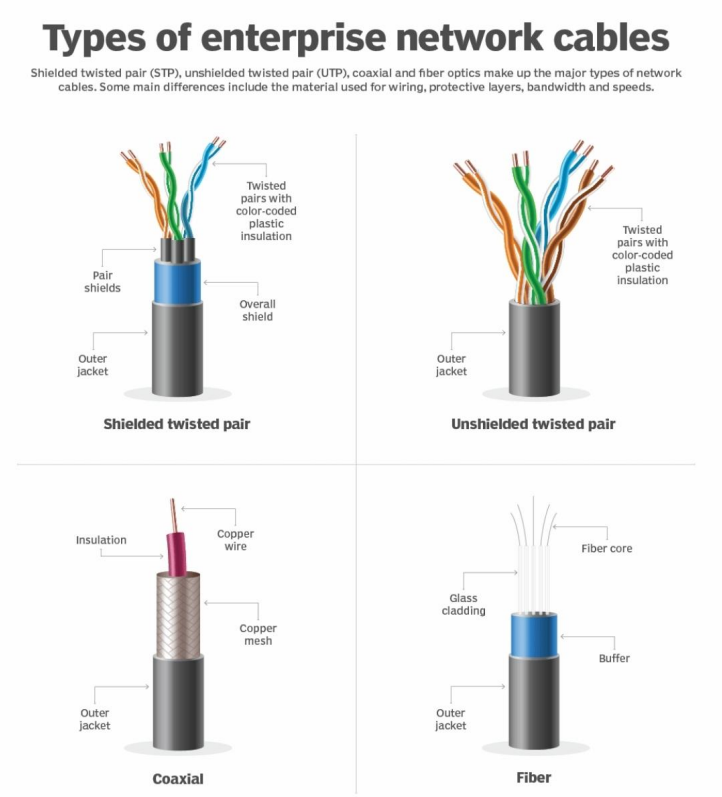


- Uses a physical metal medium to transmit electrical waves (i.e., voltage) to other computers and computing devices

Wired Connections - Materials

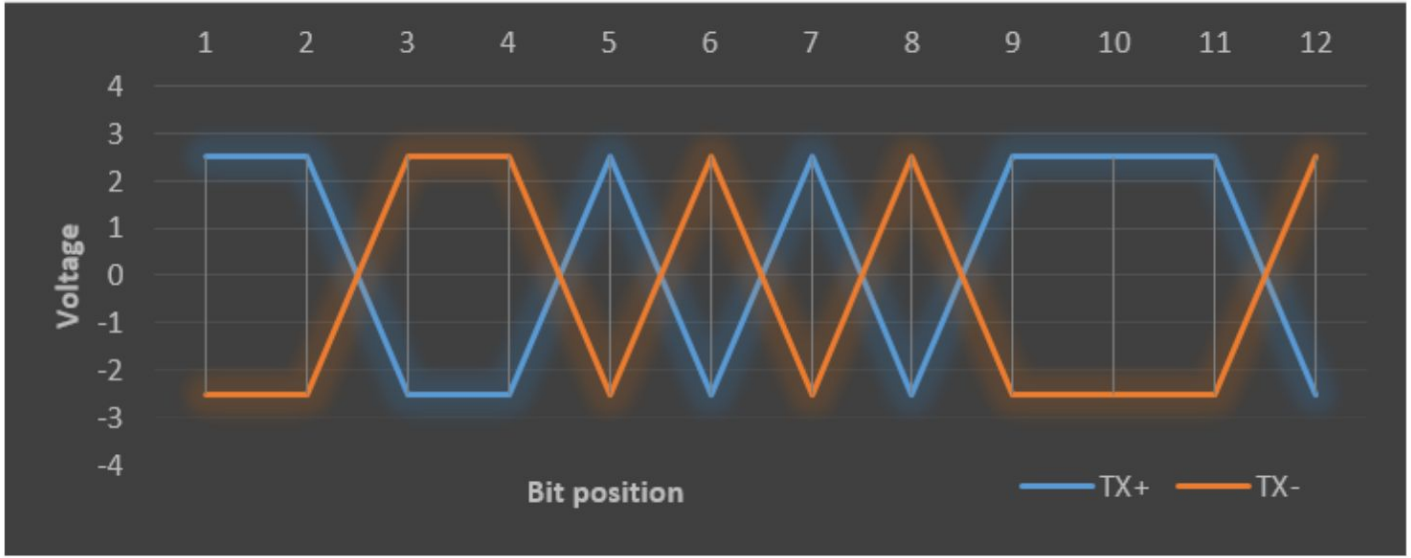


Wired Connections - Types of Wires



Wired Connections - Electrical Signals

Position:	1	2	3	4	5	6	7	8	9	10	11	12
Bits:	1	1	0	0	1	0	1	0	1	1	1	0
TX+	2.5	2.5	-2.5	-2.5	2.5	-2.5	2.5	-2.5	2.5	2.5	2.5	-2.5
TX-	-2.5	-2.5	2.5	2.5	-2.5	2.5	-2.5	2.5	-2.5	-2.5	-2.5	2.5



Wired Connections - Types of Wires

Characteristics	UTP	STP	Coaxial Cables	Fiber Optic Cables
Bandwidth	10 Mbps - 100 Mbps	10 Mbps - 100 Mbps	10 Mbps	100 Mbps -1 Gbps
Maximum cable segment	100 meters	100 meters	200 - 500 meters	2 k.m. - 100 k.m.
Interference rating	Poor	Better than UTP	Better than Twisted Pair Cable	Very good as compared to any other cable
Installation cost	Cheap	Costly than UTP	Costlier than twisted pair wires	Costliest to install
Bend radius	360 degrees / feet	360 degrees / feet	360 degrees / feet or 30 degrees / feet	30 degrees / feet
Security	Low	Low	Low	High

Wired Connection - Categories of Wires

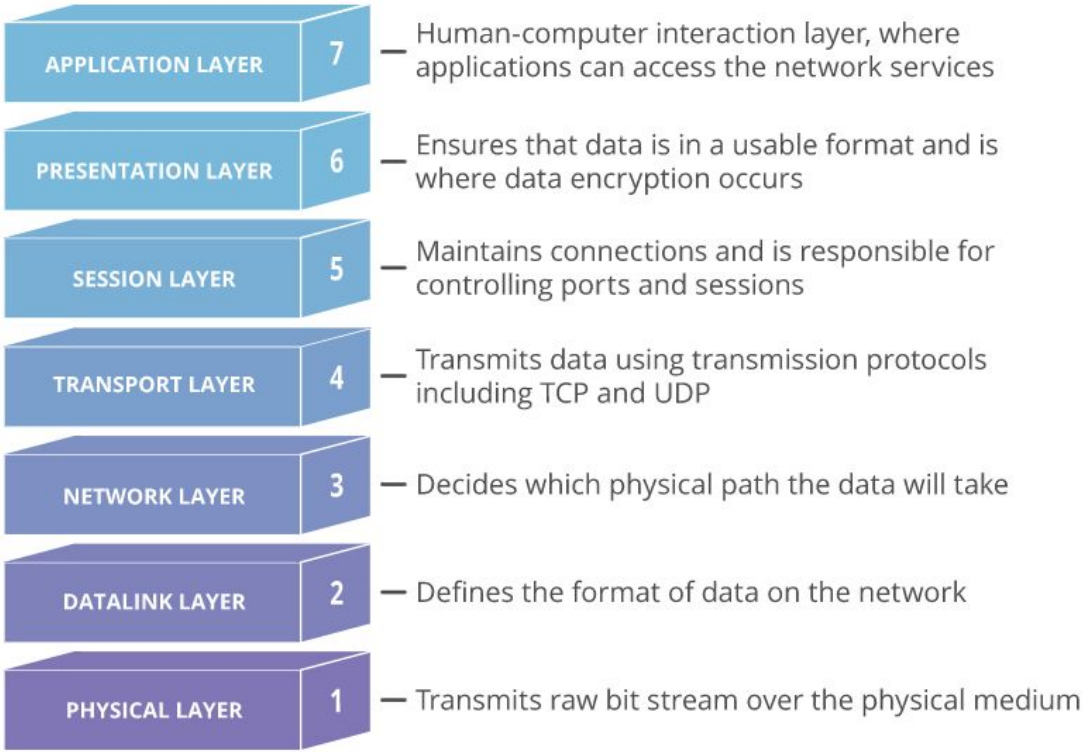
Enterprise twisted-pair cable types compared

Category	Maximum Bandwidth	Maximum Data Rate	Maximum Distance Supported	Common Applications
Cat1	0.4 MHz	1 Mbps	--	Telephone and modem lines
Cat2	4 MHz	4 Mbps	--	Telephone
Cat3	16 MHz	10 Mbps	100 meters	10Base-T Ethernet
Cat4	20 MHz	16 Mbps	100 meters	Token ring
Cat5	100 MHz	100 Mbps	100 meters	100Base-T Ethernet
Cat5e	100 MHz	1 Gbps	100 meters	100Base-T Ethernet Home use
Cat6	250 MHz	1 Gbps	100 meters 37 meters for 10 Gb data rates	Gigabit Ethernet Commercial establishments
Cat6a	500 MHz	10 Gbps	100 meters	Gigabit Ethernet Enterprise data centers Commercial establishments
Cat7	600 MHz	10 Gbps	100 meters	10 Gbps core infrastructure
Cat7a	1,000 MHz (1 GHz)	10 Gbps	100 meters 50 meters for 40 Gb data rates	10 Gbps core infrastructure
Cat8	200 MHz (2 GHz)	Cat8.1: 25 Gbps Cat8.2: 40 Gbps	30 meters	25/40 Gbps core infrastructure

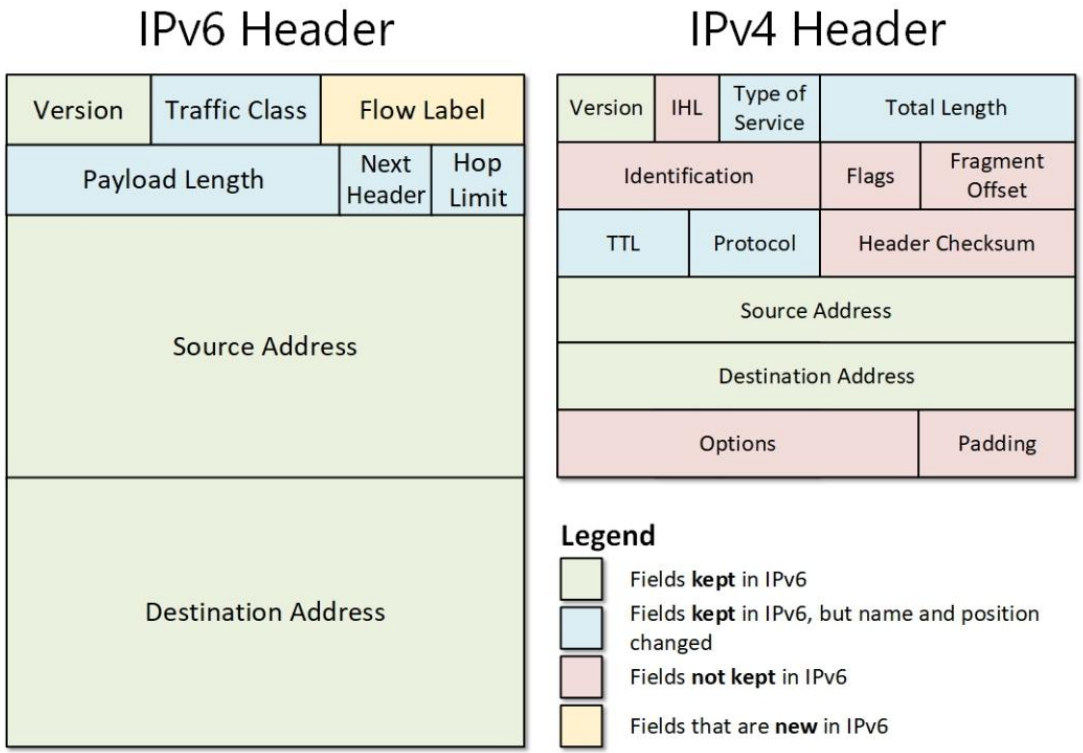
Protocols

- Acts as the “language” the computers use to communicate
- There are many layers to protocols
- Many applications use Transmission Control Protocol (TCP) or User Datagram Protocol (UDP)
  - Most other protocols are built off TCP or UDP

Protocols - Layers



Protocols - IPv4 vs IPv6



Protocols - TCP vs UDP

TCP	UDP
Secure	Unsecure
Connection-Oriented	Connectionless
Slow	Fast
Guaranteed Transmission	No Guarantee
Used by Critical Applications	Used by Real-Time Applications
Packet Reorder Mechanism	No Reorder Mechanism
Flow Control	No Flow Control
Advanced Error Checking	Basic Error Checking (Checksum)
20 Bytes Header	8 Bytes Header
Acknowledgement Mechanism	No Acknowledgement
Three-Way Handshake	No Handshake Mechanism
DNS, HTTPS, FTP, SMTP etc.	DNS, DHCP, TFTP, SNMP etc.

Protocols - TCP vs UDP

TCP Segment Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Sequence Number			
64	Acknowledgment Number			
96	Data Offset	Res	Flags	Window Size
128	Header and Data Checksum		Urgent Pointer	
160...	Options			

UDP Datagram Header Format

Bit #	0 – 7	8 – 15	16 – 23	24 – 31
0	Source Port		Destination Port	
32	Length		Header and Data Checksum	

Wireless

- Is the same idea as wired, only uses radio waves (i.e., microwaves) to transmit data instead of voltage

- About 20 times slower than wired connection

Wireless vs Wired

Wired networks

✓ Can't intercept signals down the wire; high-security
✓ Immensely high speeds (depending on cable and hardware)
✓ Incredibly long cables are still really cheap
✓ Plug and play; usually no faffing around with settings, instant-on
x Cable can be damaged

Wireless networks

✓ Convenient, allows freedom of working anywhere
✓ Less/no cables; more people connecting to one access point
x Limited signal range; speed decreases the further away you go
x Signals can be intercepted; low security
x Signals affected by other signals and radio waves
x Speed not as fast as wired networks