Introduction to Networking

Lecture 1

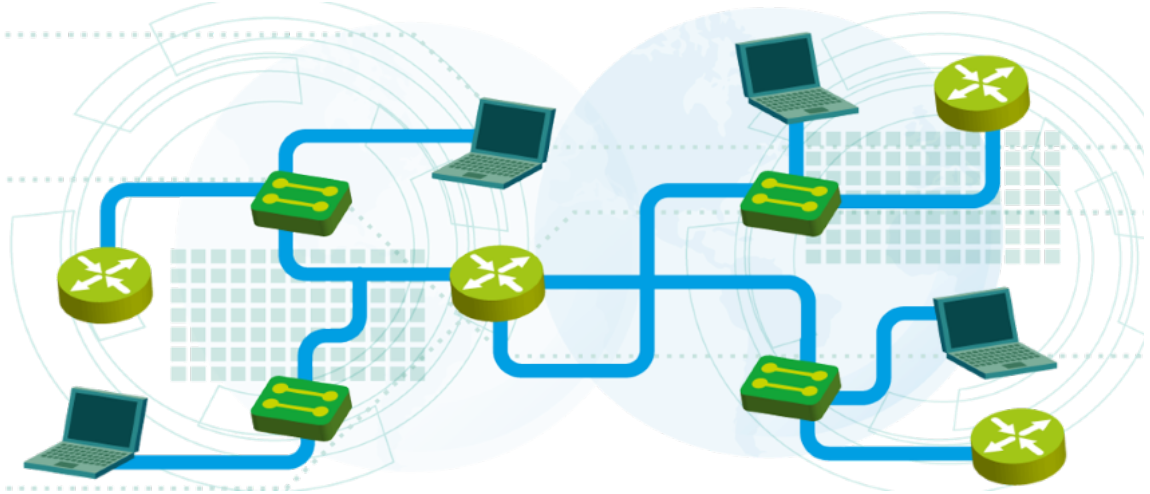
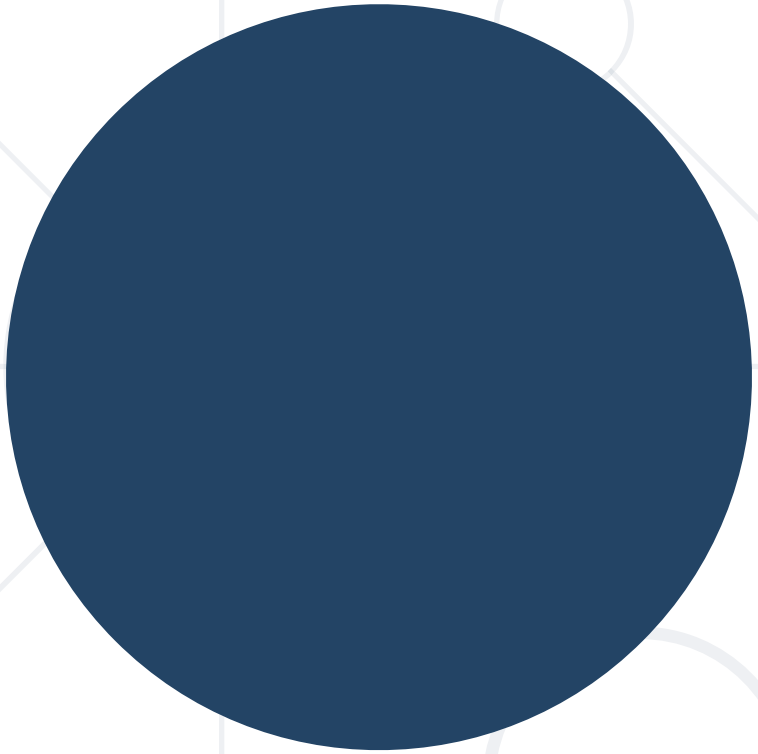


Table of Contents

Software University

1. Basic networking concepts
2. IP and MAC addresses
3. Traffic types
4. OSI and TCP/IP models
5. Cisco Packet Tracer: Introduction

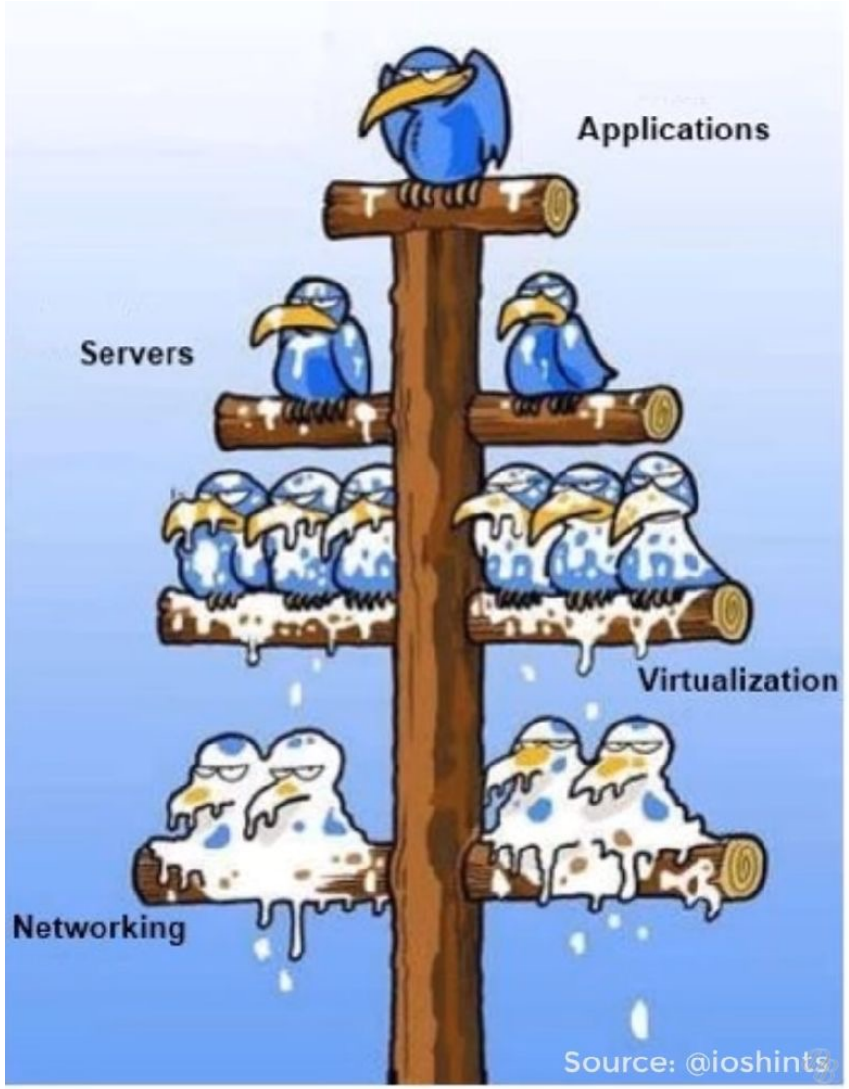


Basic networking concepts

What is a computer network?

- Multiple computers linked together
- Why? To communicate and share resources

Why computer networking is important



- Services, consumed by the users, depend on computer networks
- Can be ungrateful and “dirty”
  - when it works: “You are doing nothing!”
  - when it doesn’t work: “It is down again!”

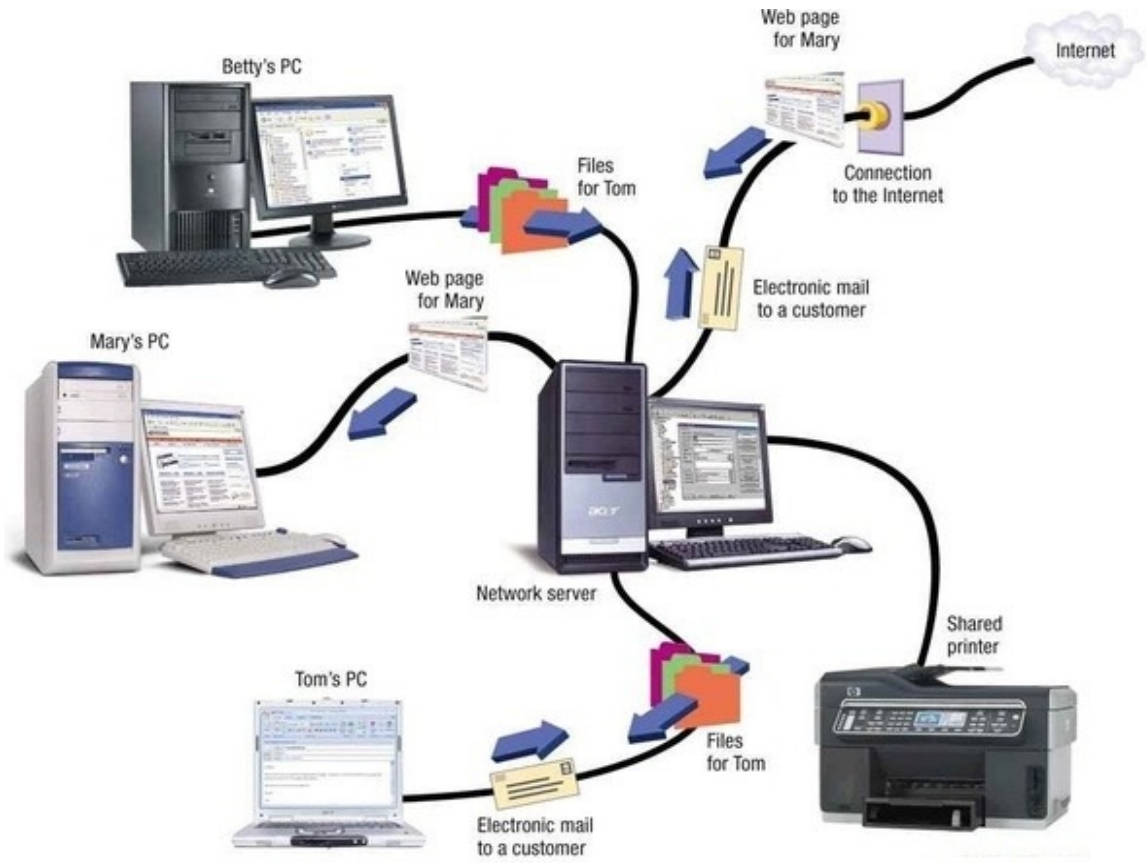
How did it start?

- ARPANET - The Advanced Research Projects Agency NETwork
- Established in 1969
- It is the first packet switching network which will use TCP/IP
- It was designed for scientific purposes and to share computer resources
- ARPANET’s purpose was more academic than military

Common Types of Computer Networks

- Local Area Network (LAN)
- Wide Area Network (WAN)
- Wireless Local Area Network (WLAN)
- Storage Area Network (SAN)
- Home Area Network (HAN)

Local Area Network (LAN)

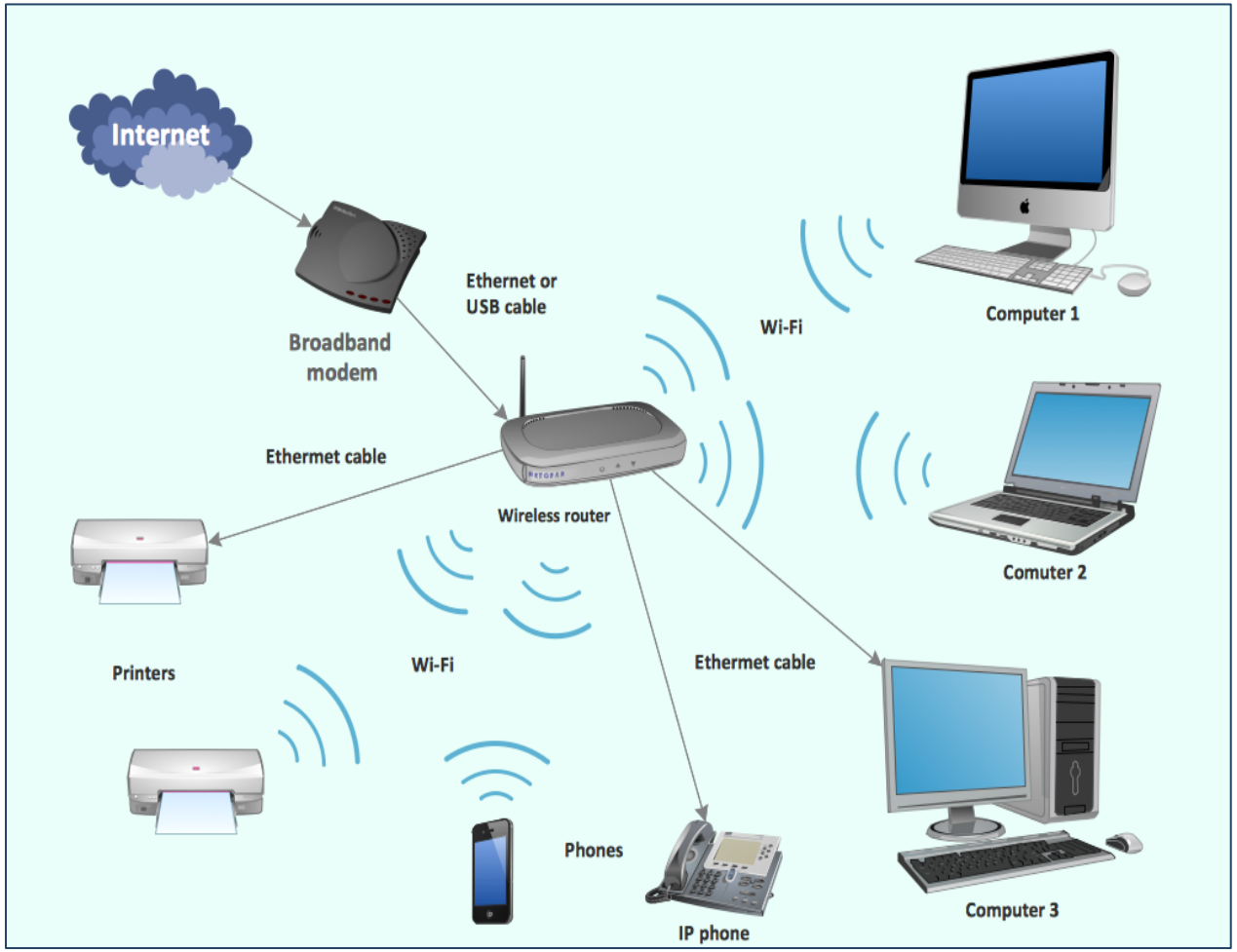


- Connects network devices over a relatively short distance
- Very useful for sharing resources such as data storage and printers

Wide Area Network (WAN)

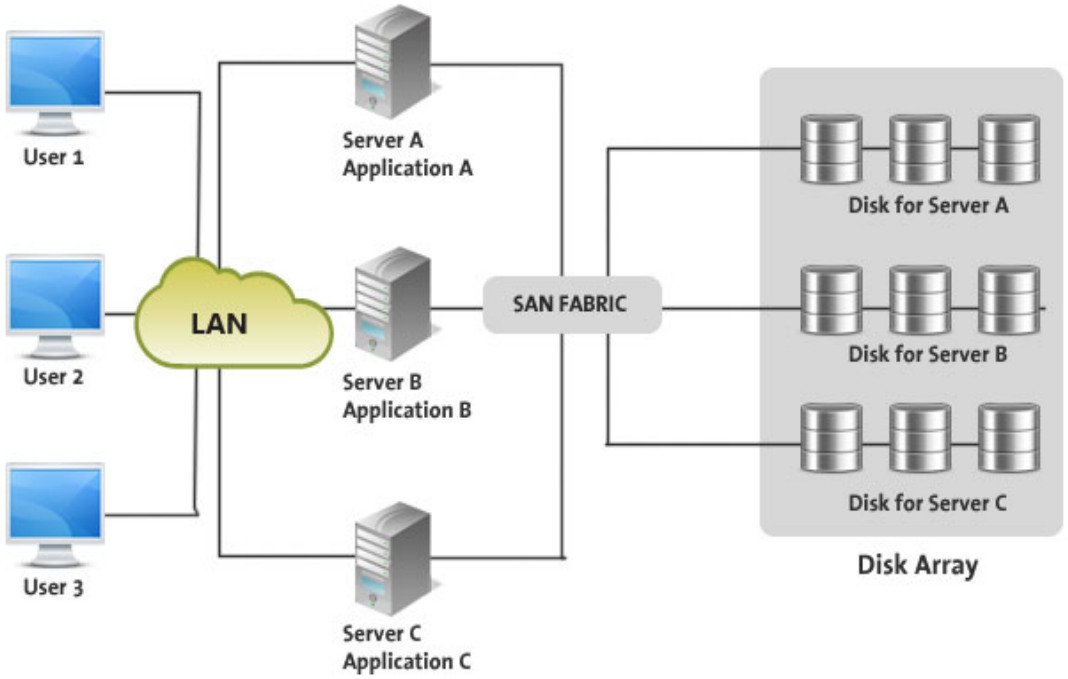
- Connects multiple LANs together
- Extends over a large geographical distance
- The Internet is the largest WAN spanning the Earth

Wireless Local Area Network (WLAN)



- Links two or more devices using a wireless distribution method
- Operates within limited area

Storage Area Network (SAN)



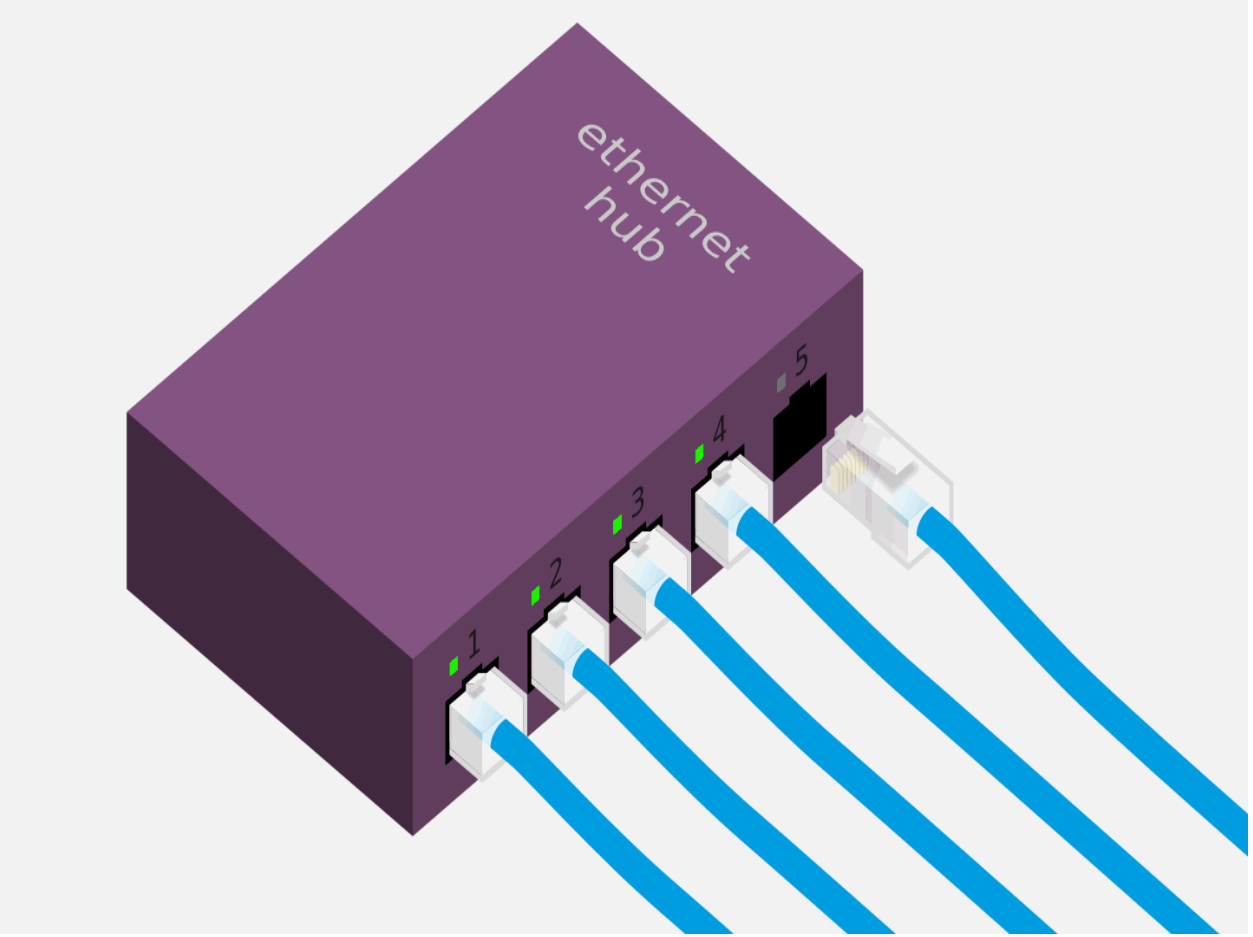
- Provides block-level network access to storage
- The OS will see it as a locally attached storage
- Common SAN protocols
  - FC
  - iSCSI
  - AoE (ATA over Ethernet)

Home Area Network (HAN)

Common Types of Networking Devices

- Hub (obsolete, not secure and very slow)
- Switch
- Router
- Modem
- Firewall
- Bridge (like a Switch, fewer ports)
- Repeater (like a Hub, it just amplifies the signal)

Ethernet Hub



- Used to connect multiple network hosts
- Works at Layer 1 of the OSI model
- Poor security and performance
- Obsolete and now replaced by switches

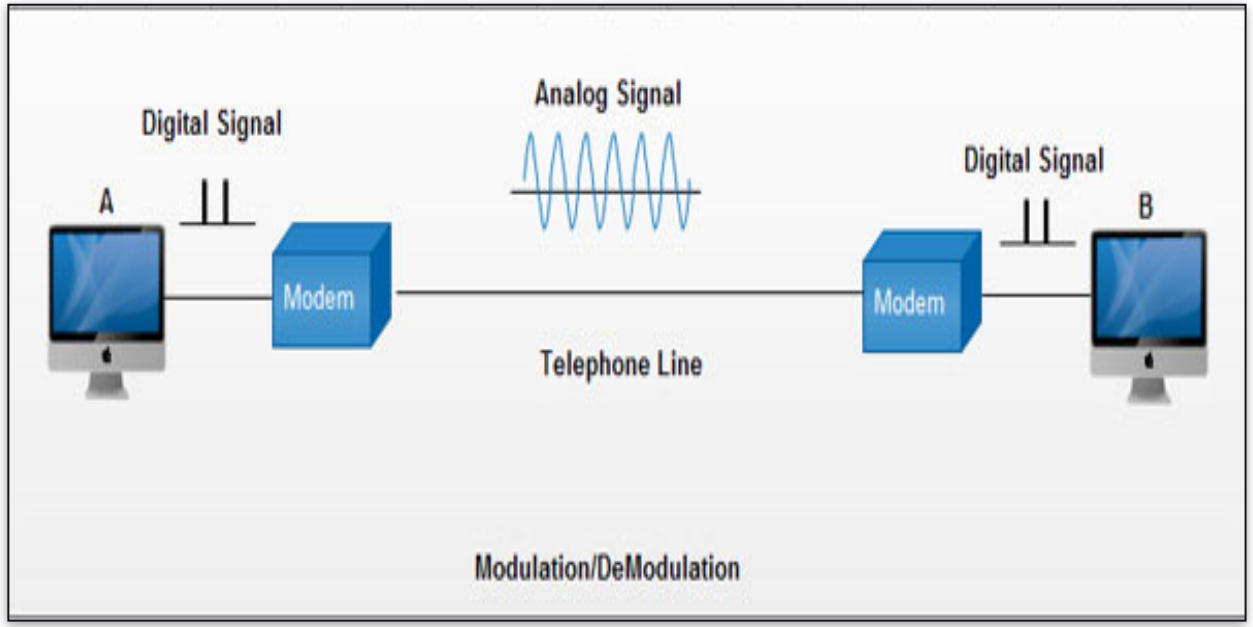
Ethernet Switch

- Provides end user connectivity
- More intelligent than a hub
- Has a MAC address table
- Provides Layer 2 functionality (and optionally L3)
- VLANs can be configured

Router

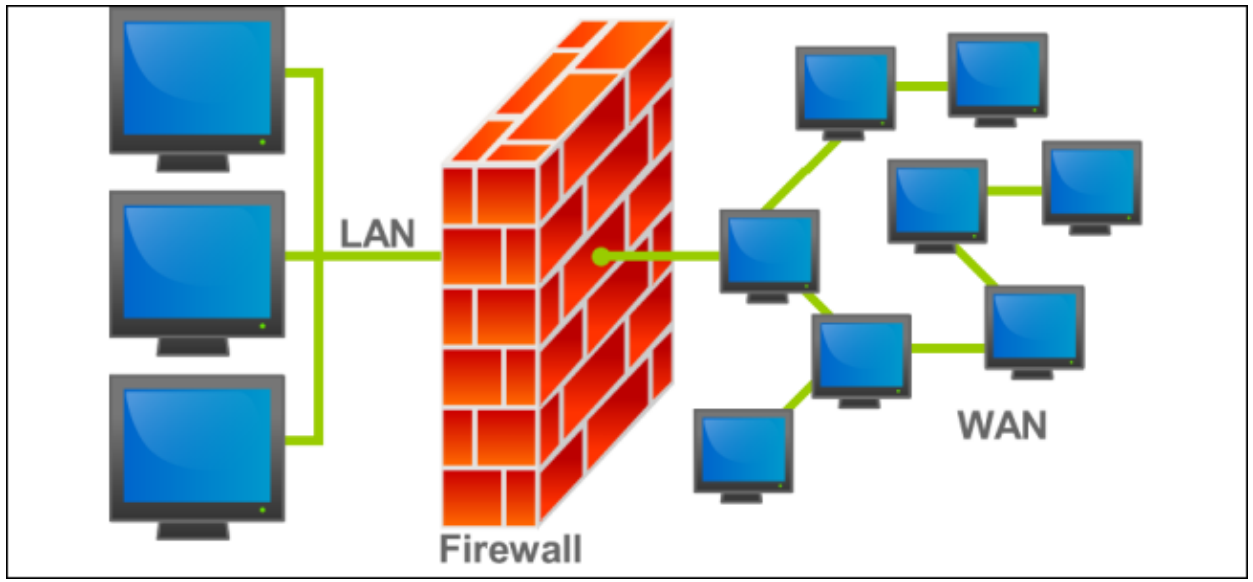
- Sends packets from one network to another
- Provides Layer 3 functionality
- Uses IP addresses to transfer packets
- “Traffic police” - directs the network traffic to different destinations

Modem



- Digital to analog (and vice versa) signal conversion: MOdulation/DEModulation

Firewall



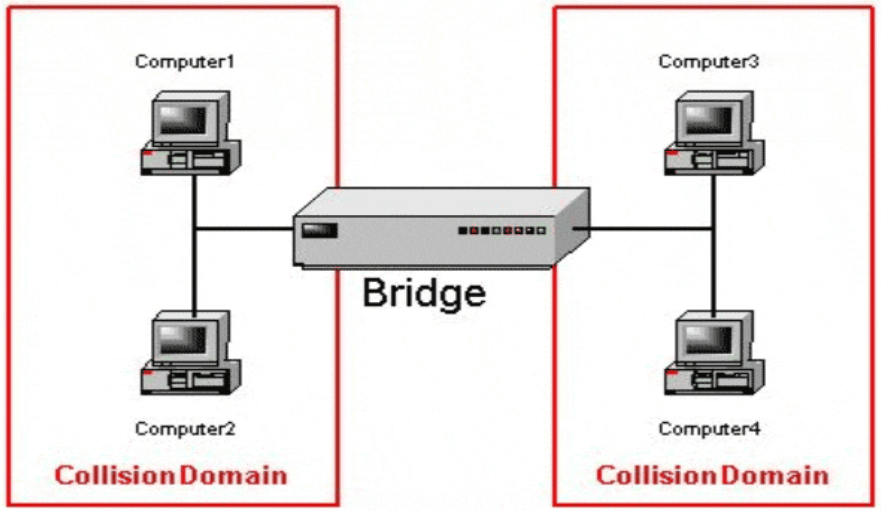
- Monitors the network traffic and makes decisions what to allow and what to block
- Protects a computer network from unauthorized access
- It may be hardware device, a software, or a combination of the two

Firewall (2)

Bridge and repeater

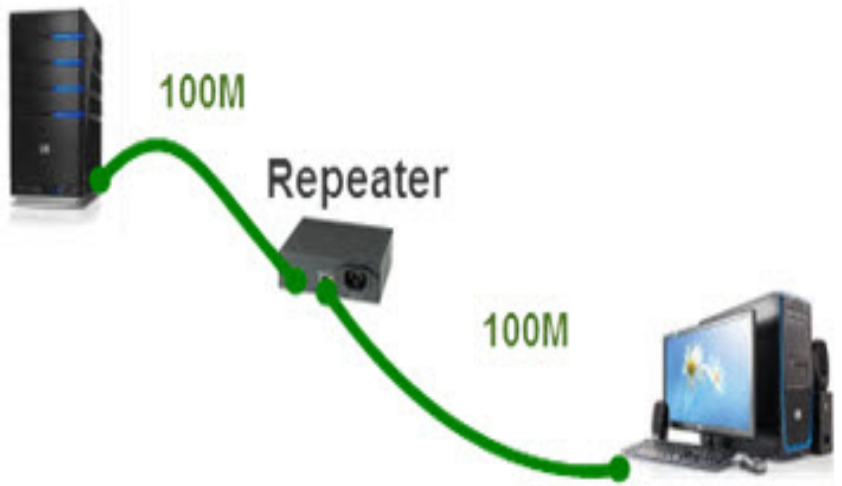
Bridge

- Similar to a Switch
- Works at Layer 2

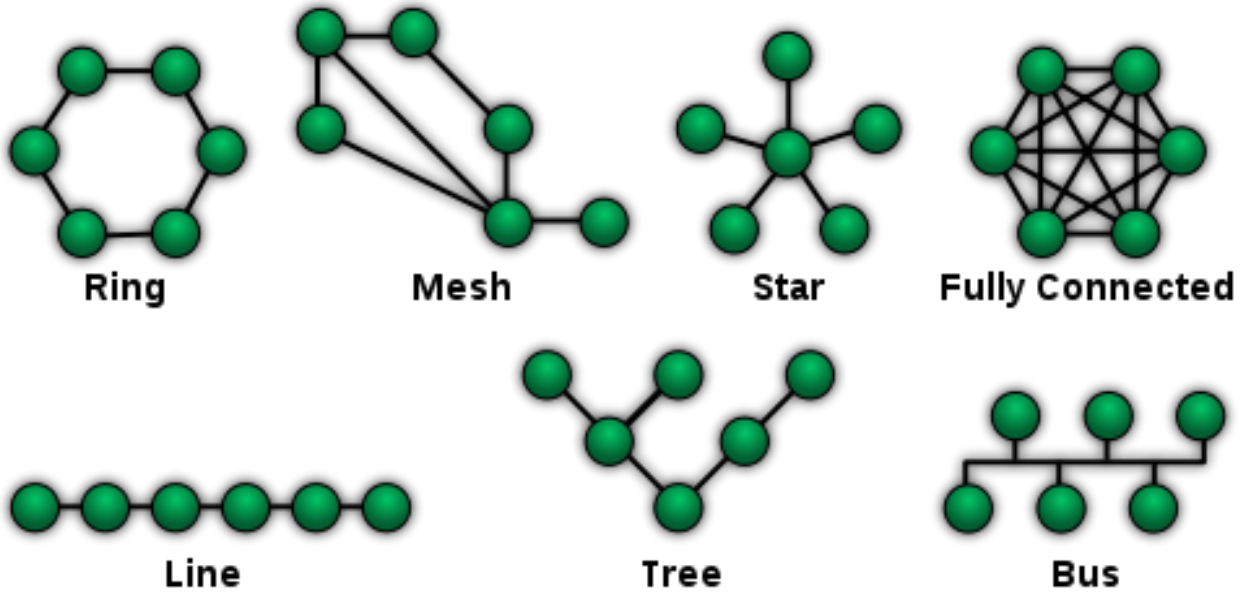


Repeater

- Similar to a Hub
- Works at Layer 1

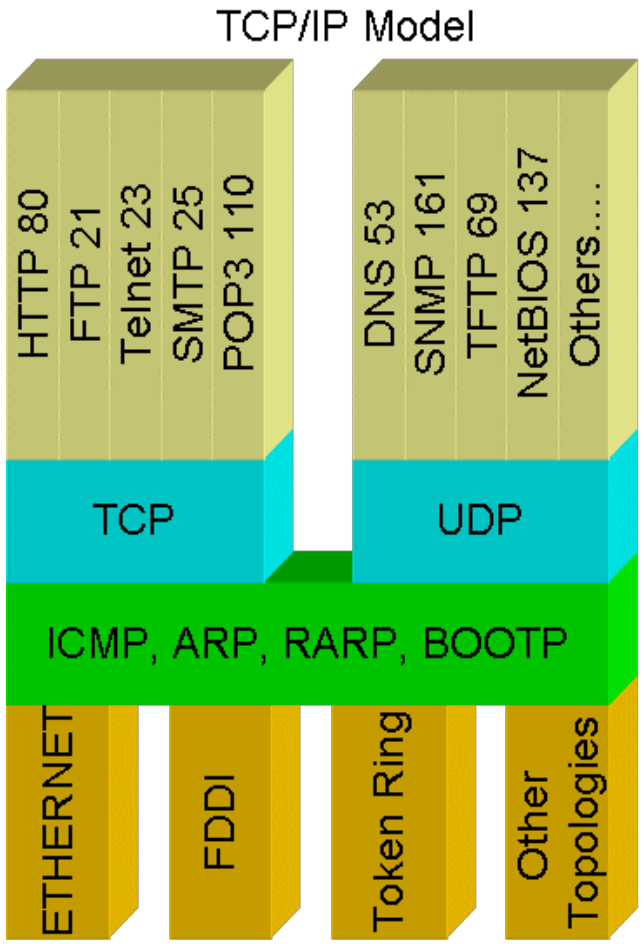


Types of Network Topologies



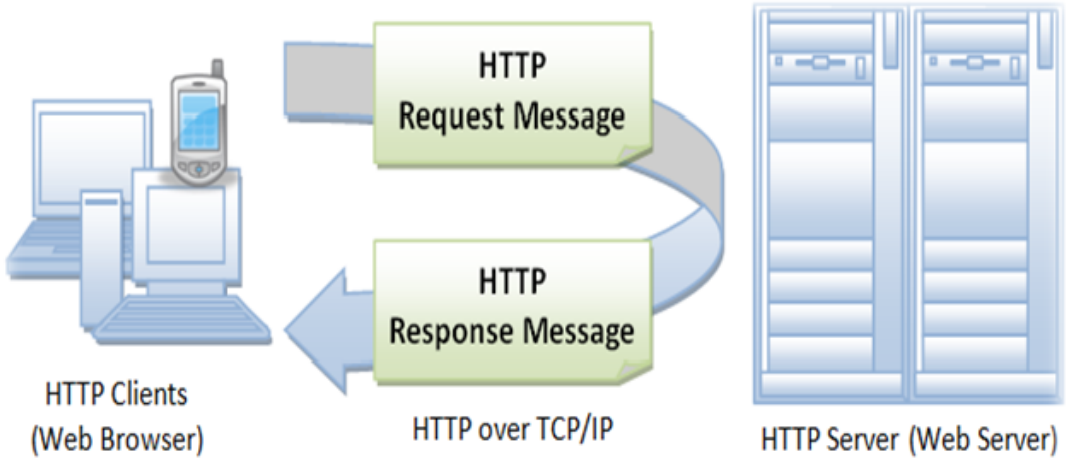
- Physical vs logical topologies
- (extended) star is the most common
- Hybrid topologies

Networks Protocols



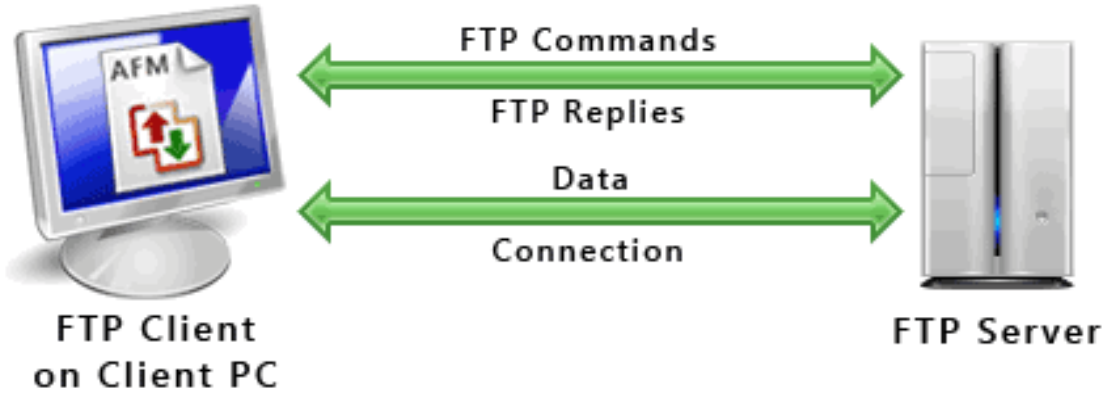
- Define a common format and set of rules for exchanging messages between network devices
- Common protocols:
  - HTTP
  - FTP
  - SMTP
  - DNS
  - DHCP
  - RDP

Hyper text transfer protocol (HTTP)



- Set of rules to transfer files - text, images, sound, video and other multimedia on the World Wide Web
- This is how our browsers talk to web servers

File Transfer Protocol (FTP)

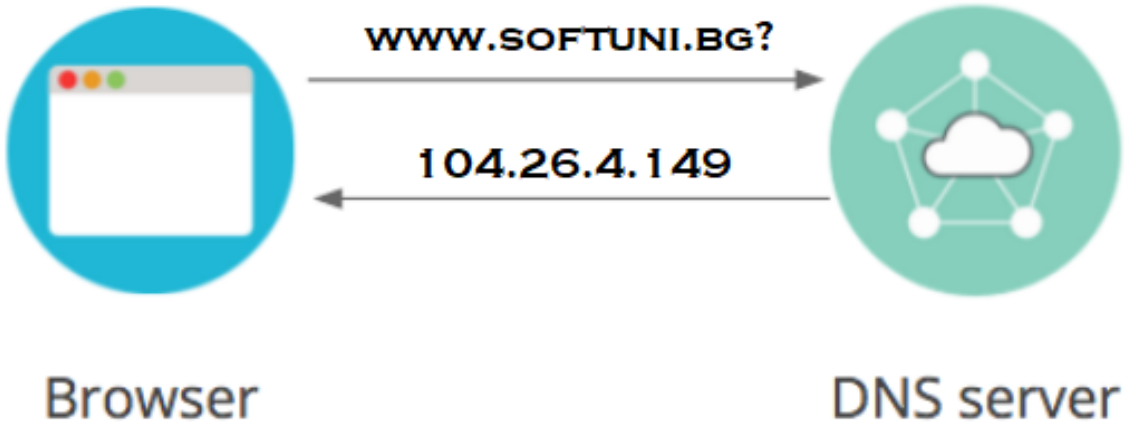


- Transfer files from one computer to another
- You can connect anonymously or with username and password

Simple Mail Transfer Protocol (SMTP)

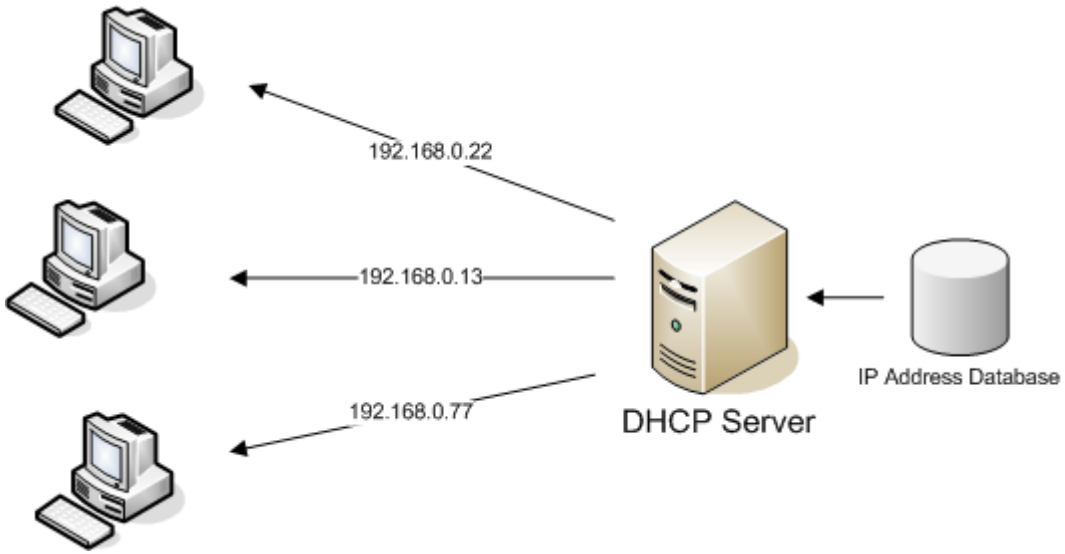
- Can be used for:
  - Server-to-server email transport
  - Client-to-server email transport

Domain Name System (DNS)



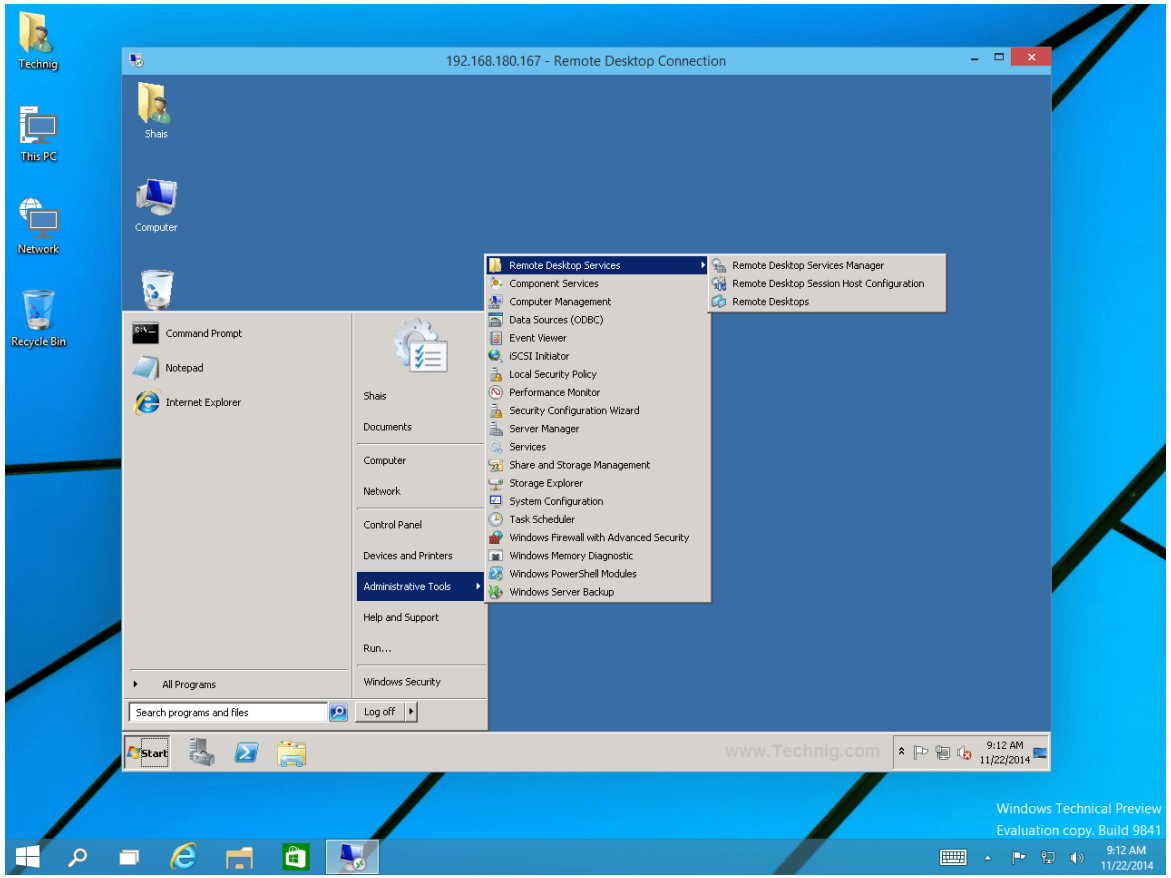
- Translates domain names into IP addresses (and much more)
- It is hierarchical and distributed database

Dynamic Host Configuration Protocol (DHCP)



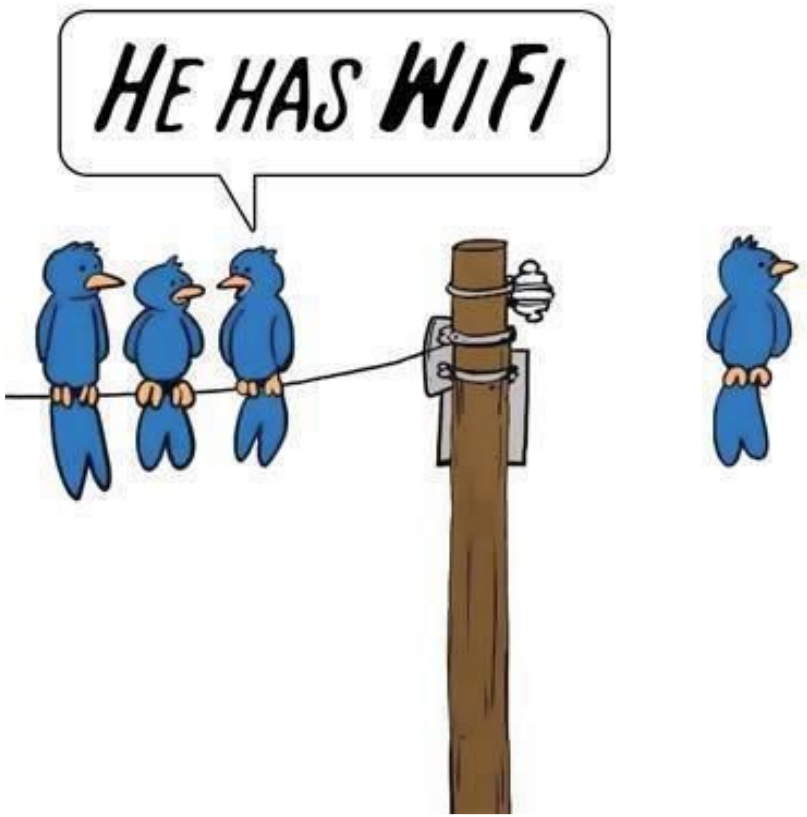
- Allows a computer to get an IP address from a special server
- Uses client-server architecture

Remote Desktop Protocol (RDP)



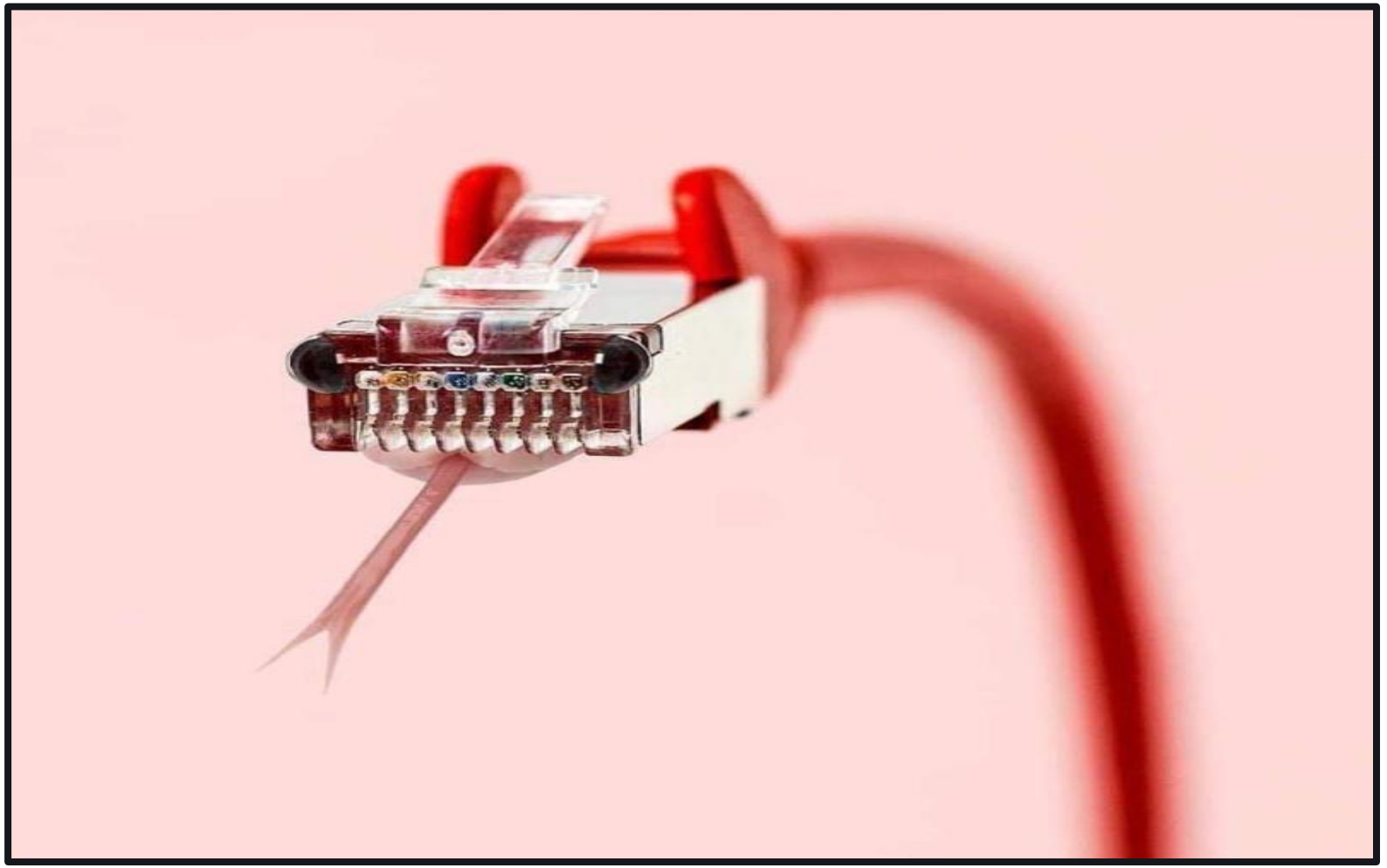
- Provides a graphical interface to connect to another computer over the network
- Can also transfer other resources between the local and remote system, like audio, disk drives and clipboard

Common Types of Media

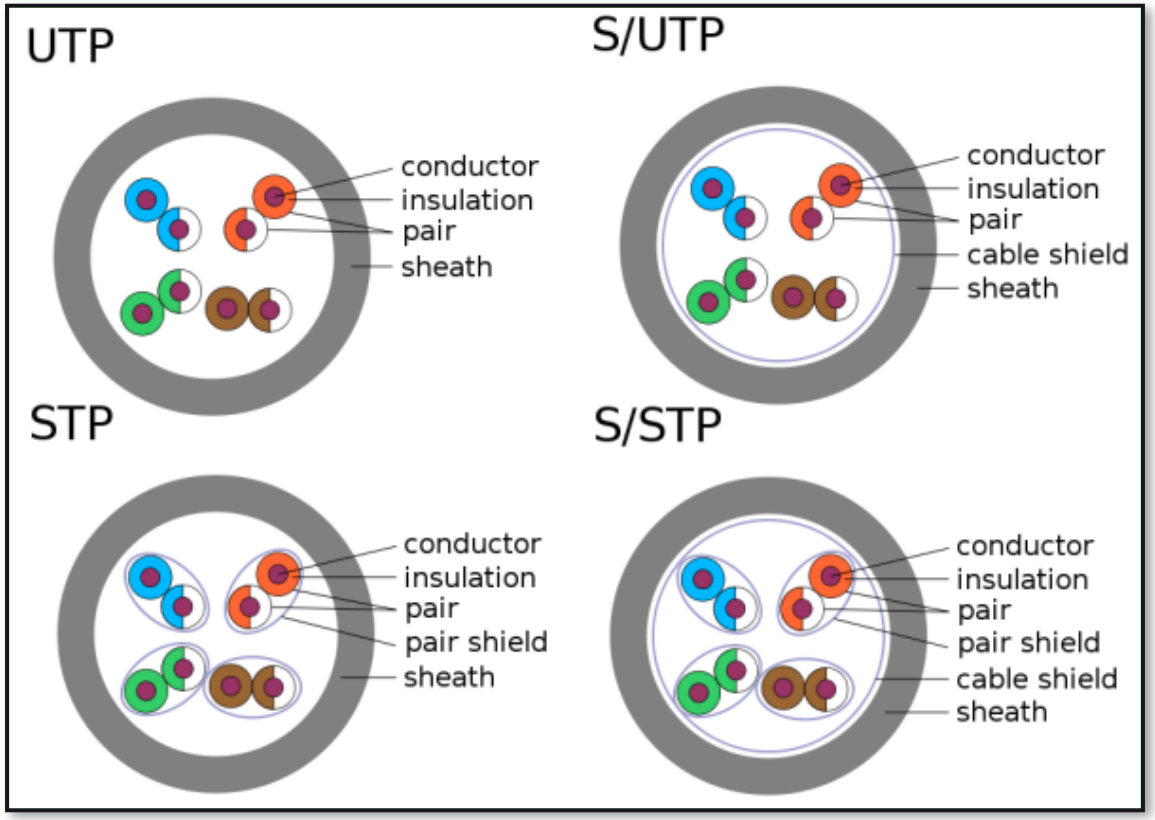


- “X”TP (“something” Twisted Pair). The “twist” idea introduced by Alexander Bell in 1881
- Coaxial Cable
- Fiber Optic
- Wireless

Let’s talk about cables…

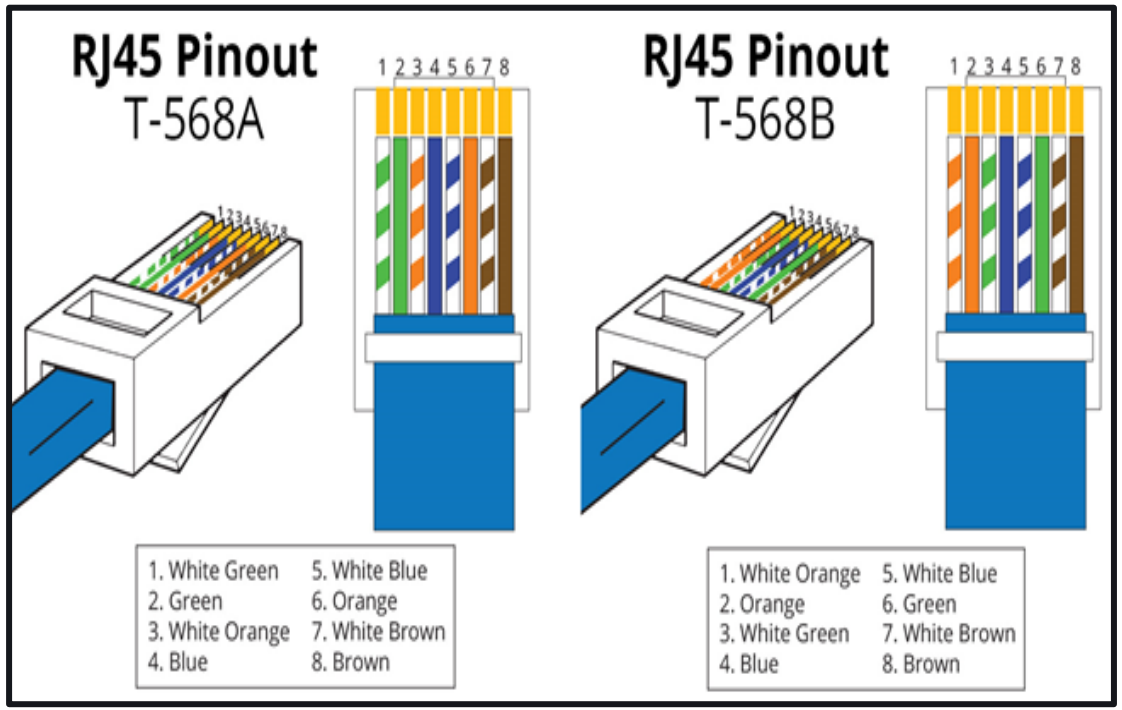


“X”TP (“something” Twisted Pair)



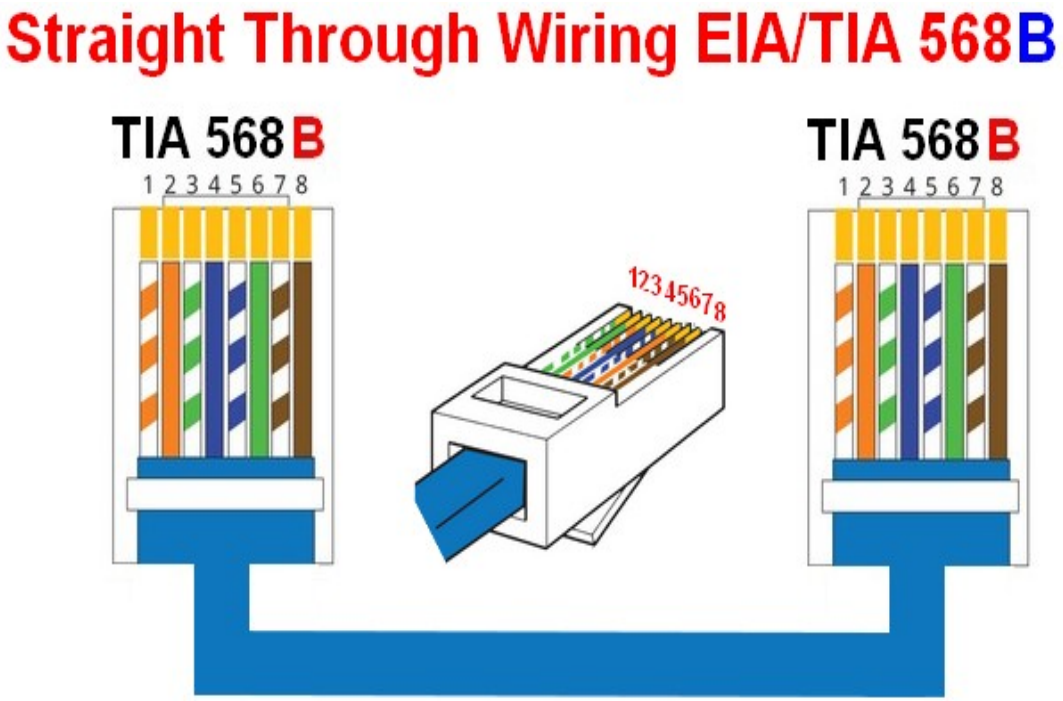
- UTP – Unshielded Twisted Pair
- S/UTP – Screened UTP
- STP – Shielded Twisted Pair
- S/STP - Screened STP

EIA/TIA Standards



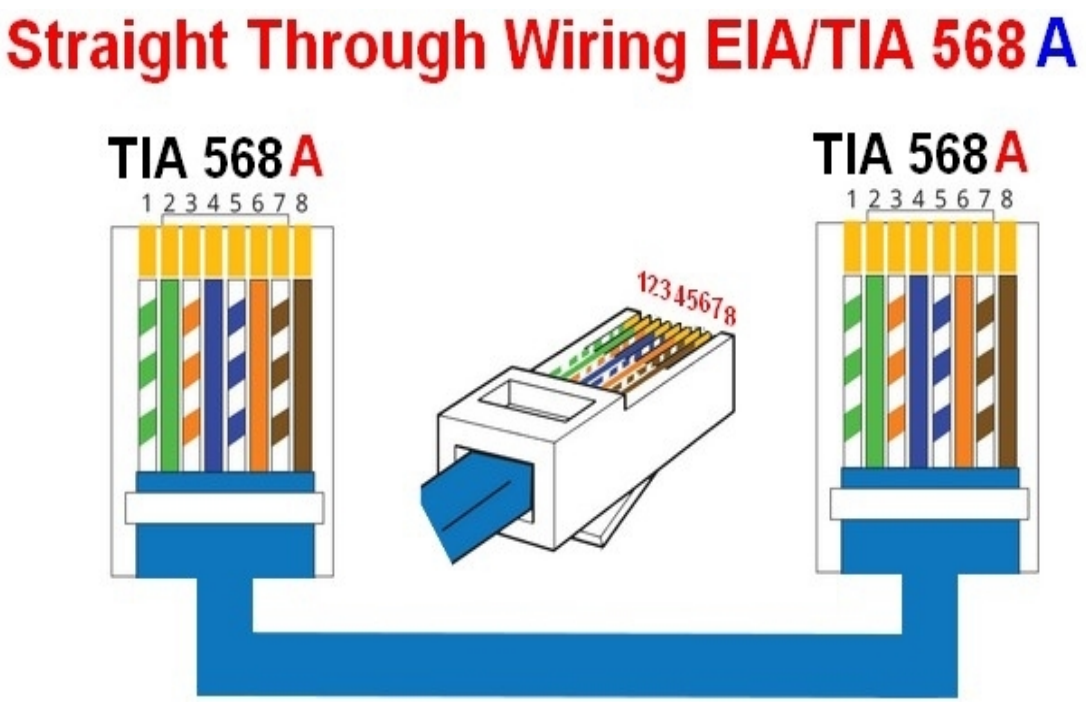
- EIA = Electronic Industries Alliance
  TIA = Telecommunications Industry Association
- T568B is most frequently used

Straight-through Cable



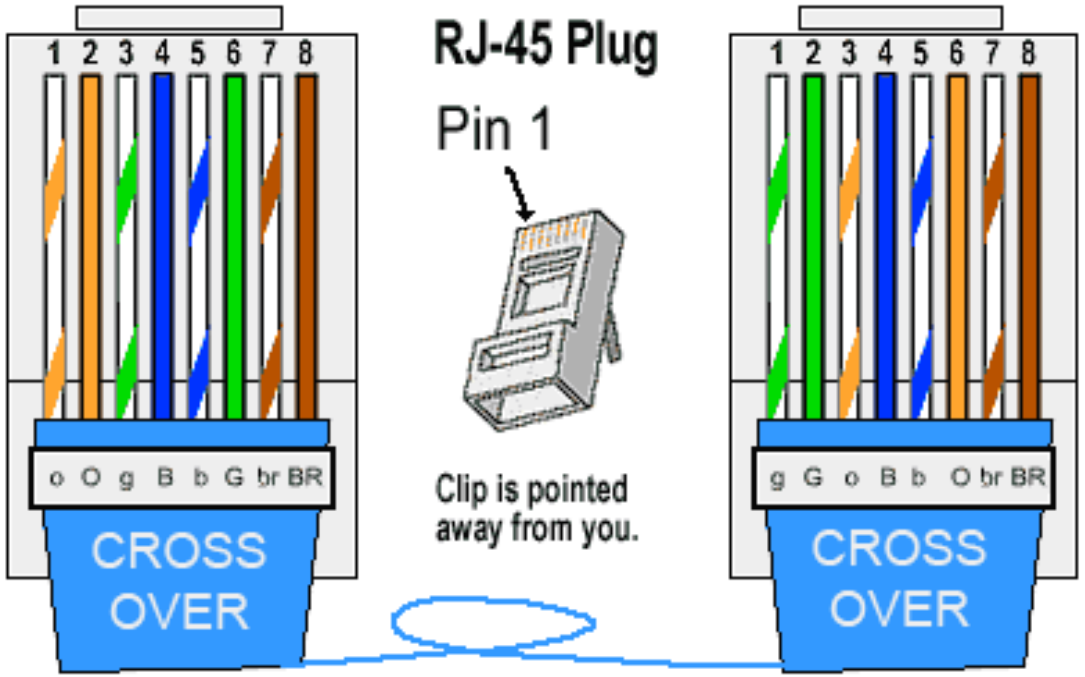
- Pin 1 → Pin 1
- Pin 2 → Pin 2, etc.
- Most commonly used to connect devices from different types:
  - Host to switch
  - Switch to router

Straight-through Cable (2)



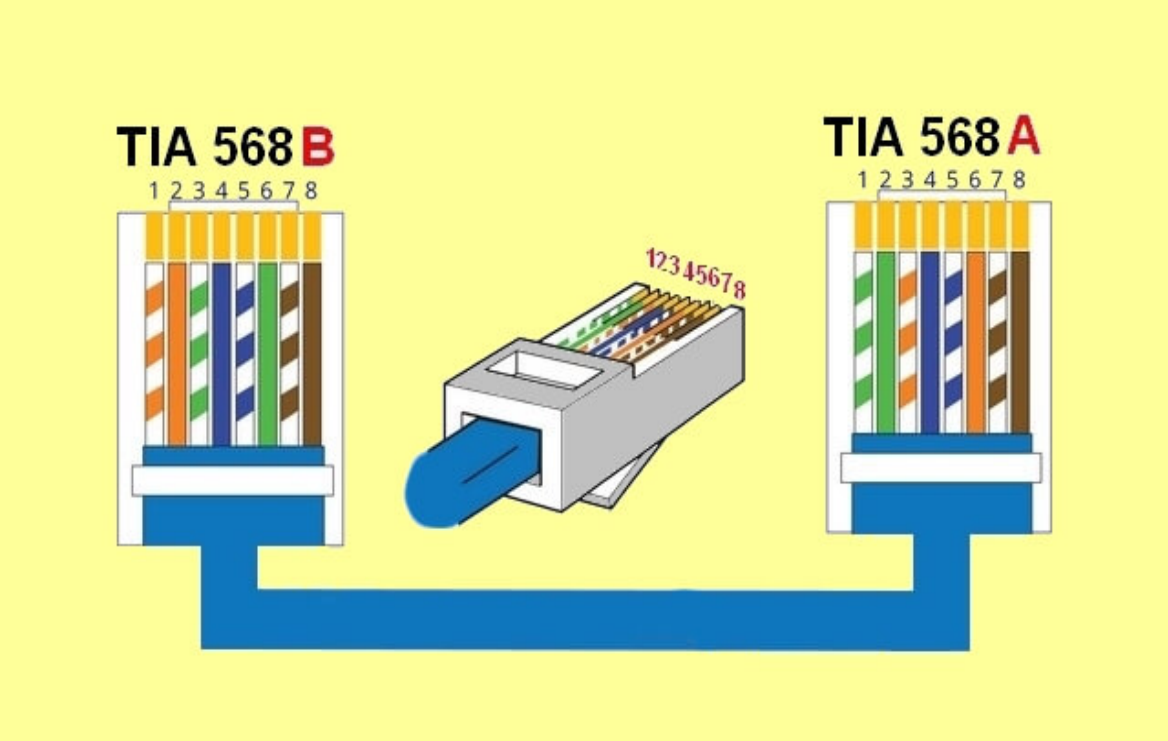
- A “straight” cable can be either:
  - T568B to T568B
    OR
  - T568A to T568A

Crossover Cable



- Pin 1 → Pin 3
- Pin 2 → Pin 6, etc.
- Most commonly used to connect two hosts directly

Crossover Cable (2)



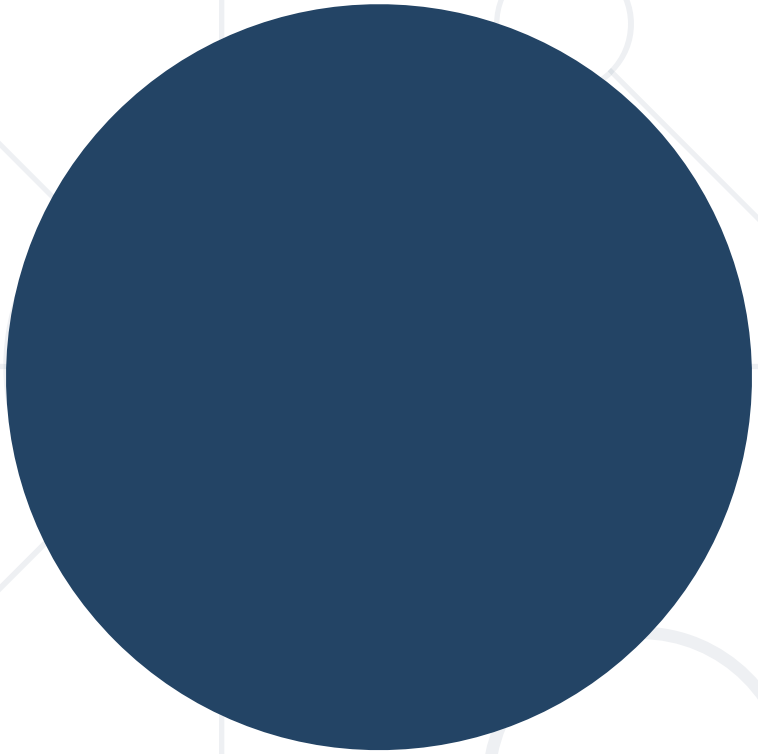
- It is T568B from one side and T568A from the other
- Used to connect devices from the same type:
  - Host to host
  - Router to router
  - Host to router (yes, no mistake)

Auto MDI/MDIX

- MDI: Medium Dependent Interface – standard wiring for end stations
- MDIX: Medium Dependent Interface Crossover - standard wiring for hubs and switches
- The good news! Auto MDI/MDIX automatically detects the required cable connection type and configures the connection appropriately

Console Cable

- Used to connect to the console of a networking device (switch, router)
- Usually a USB to Serial adapter is also required

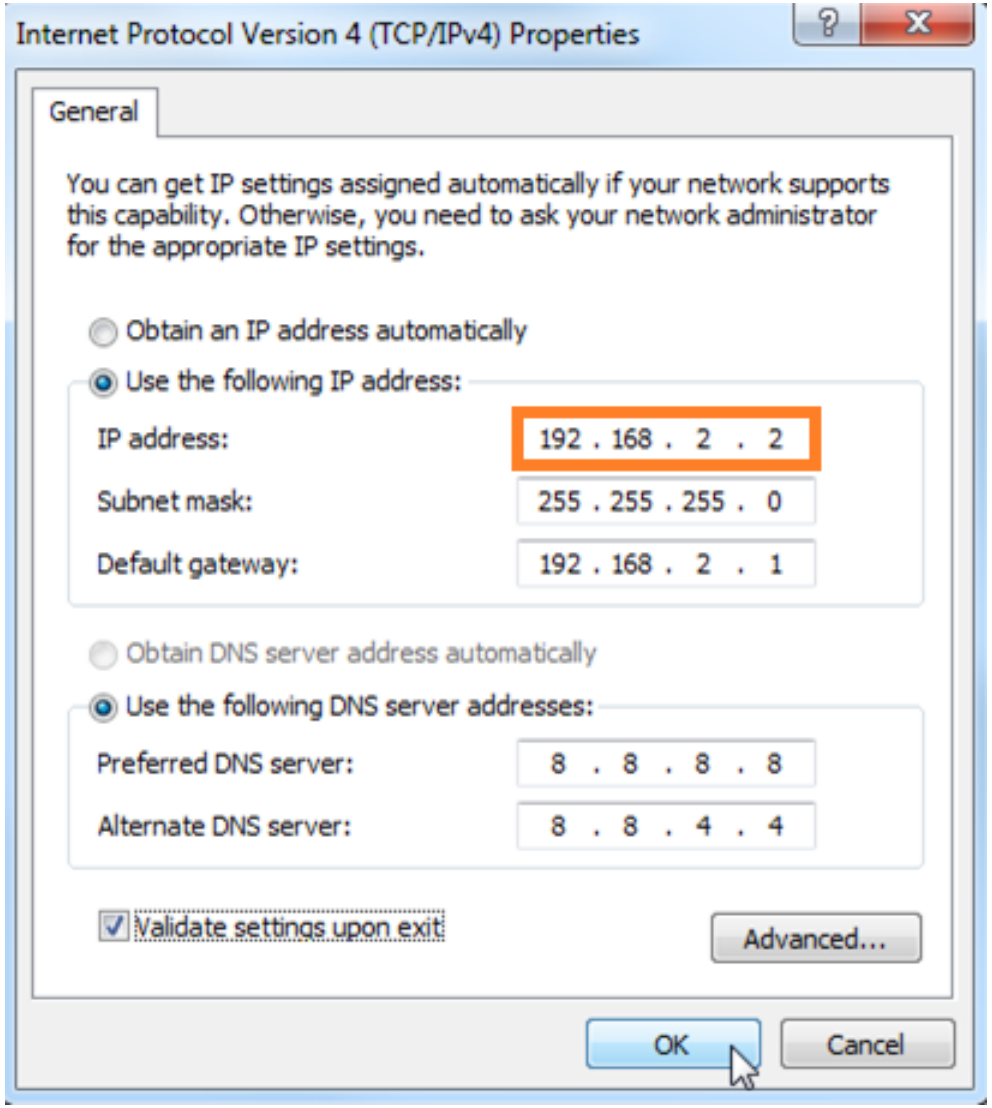


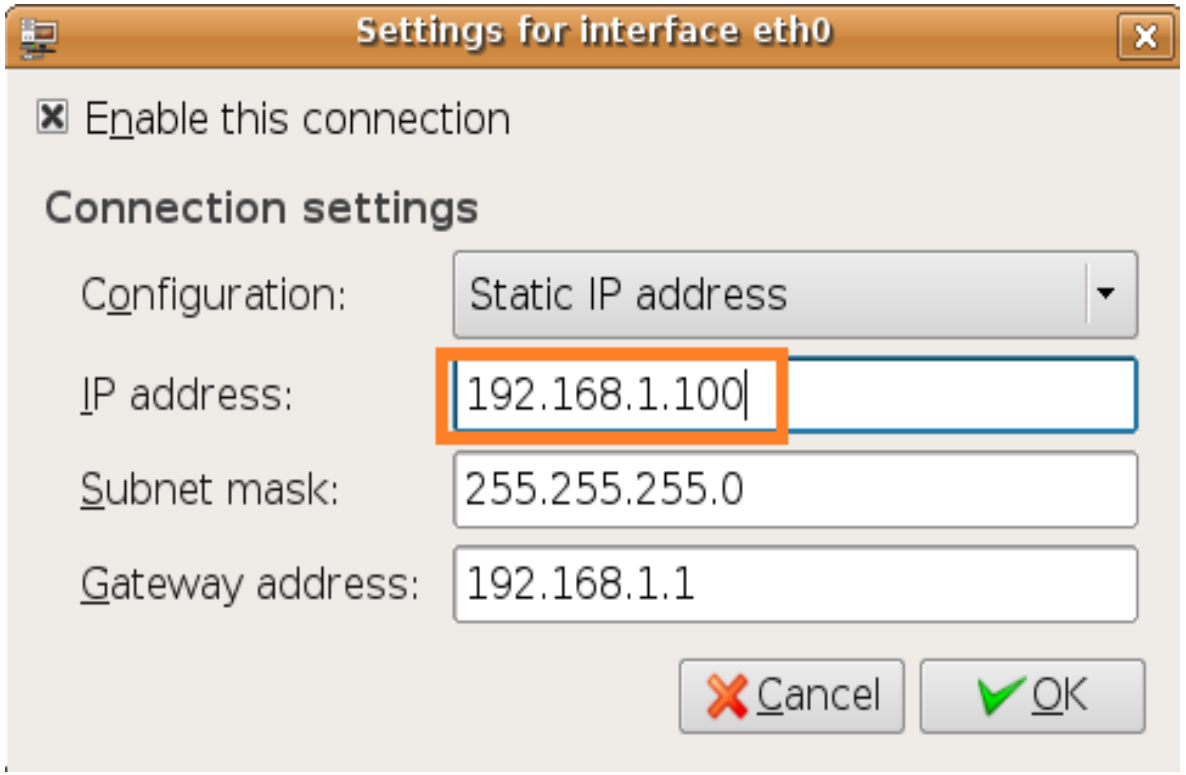
IP and MAC addresses

IP Addresses

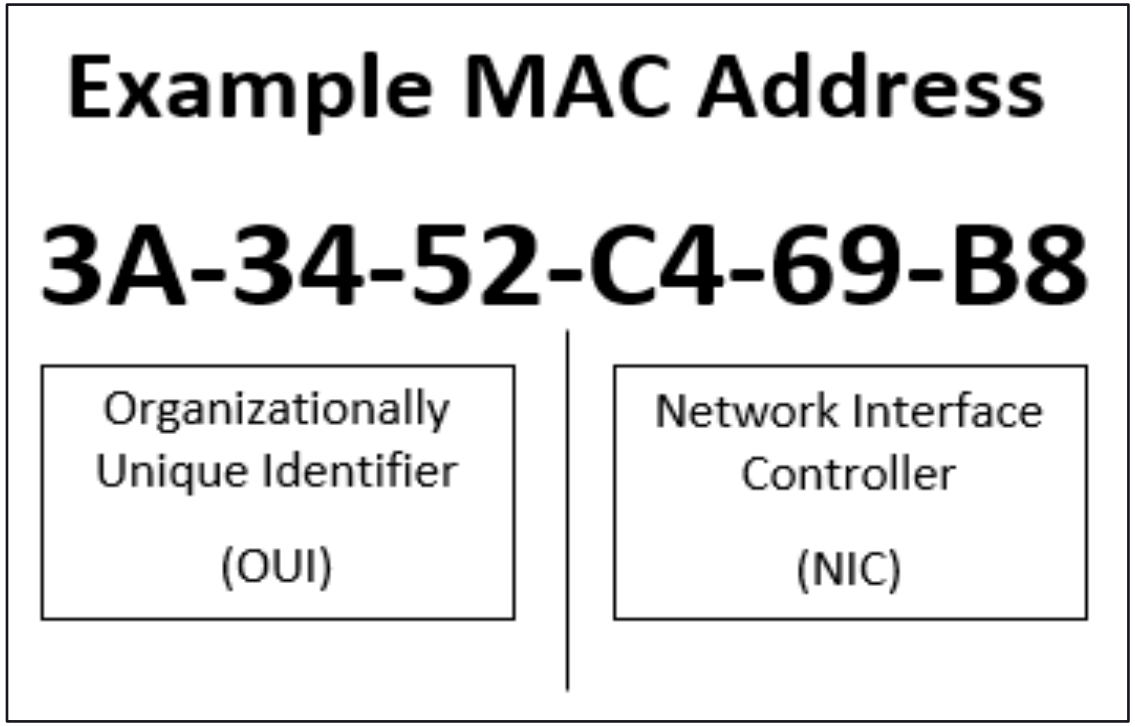
- Known as logical address
- Can be assigned to network and end devices
- Essential part in routing
- Four bytes (octets), separated with “ . “ Example: 1.3.2.8

IP Addresses (2)





MAC Addresses



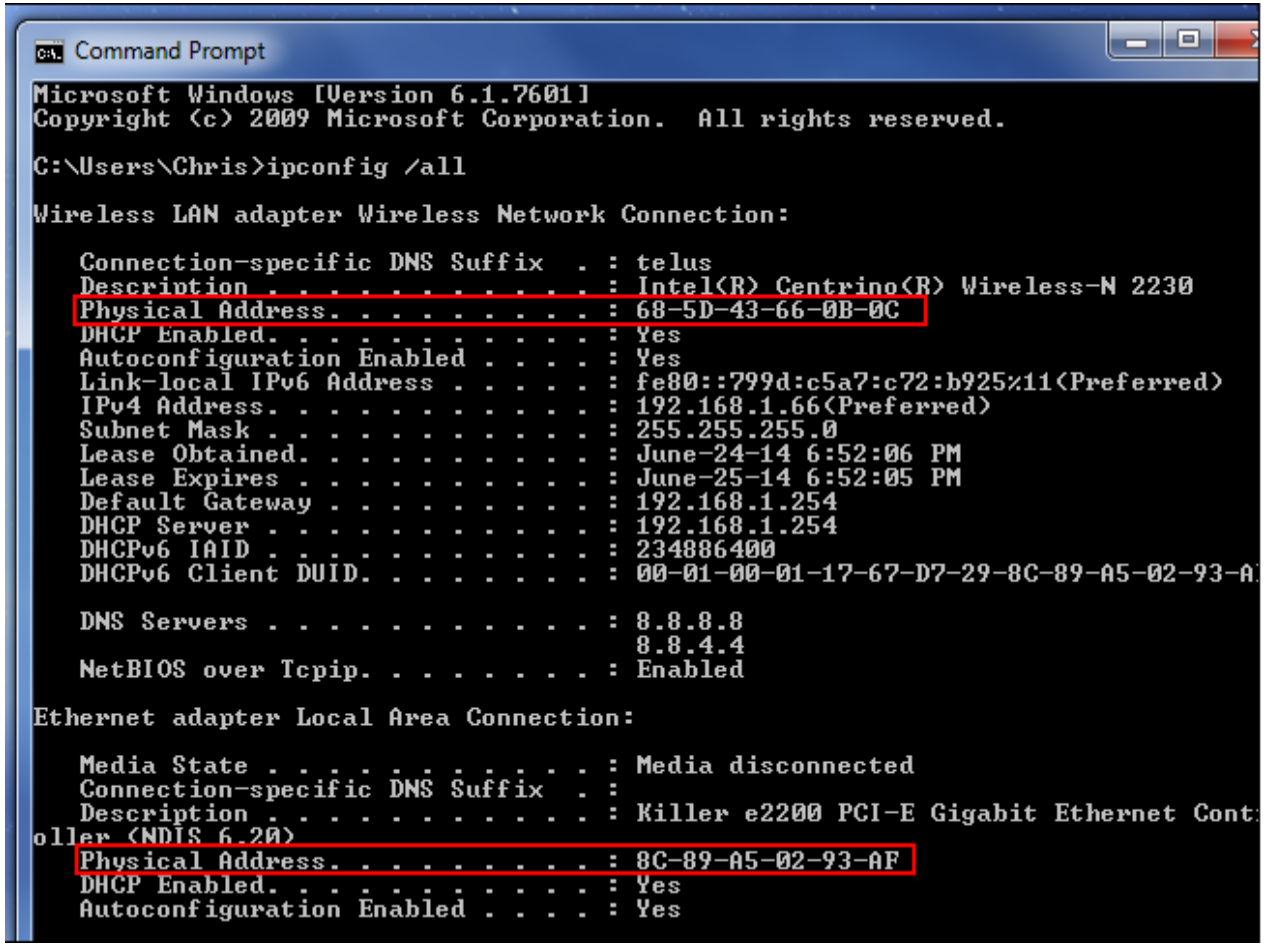
- Known as physical address
- Unique identifier assigned to network interfaces
- 48 bits or 6 bytes in a hexadecimal format (discussed later in the course)
- Can you change it?

What is a MAC Address Used for?

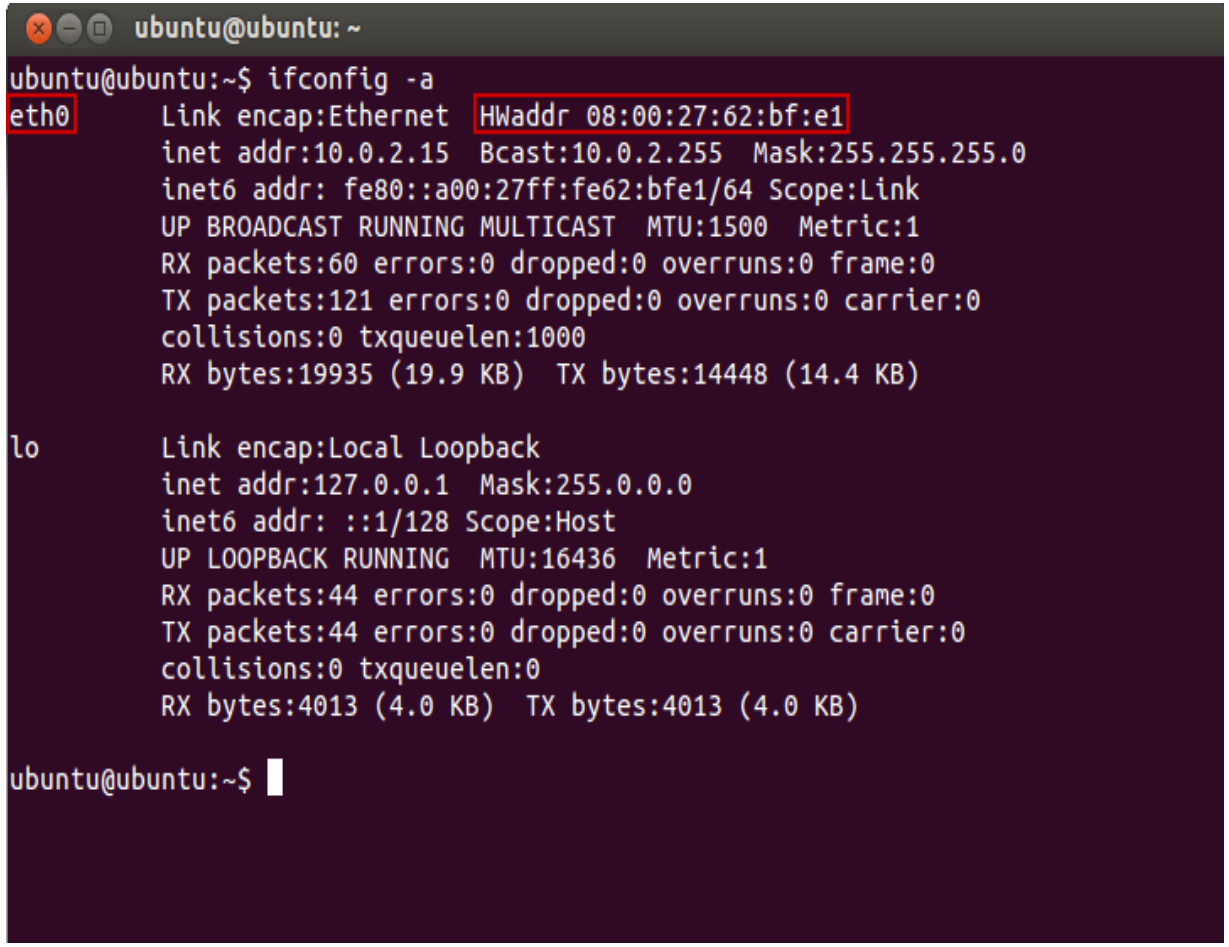
- Host-to-host communication
- Device Identification and tracking
- “Static” IP Assignment (Matched MAC -> receive IP)
- MAC Address Filtering
- MAC Address Authentication (ISPs use it, for example)

Example of MAC Address

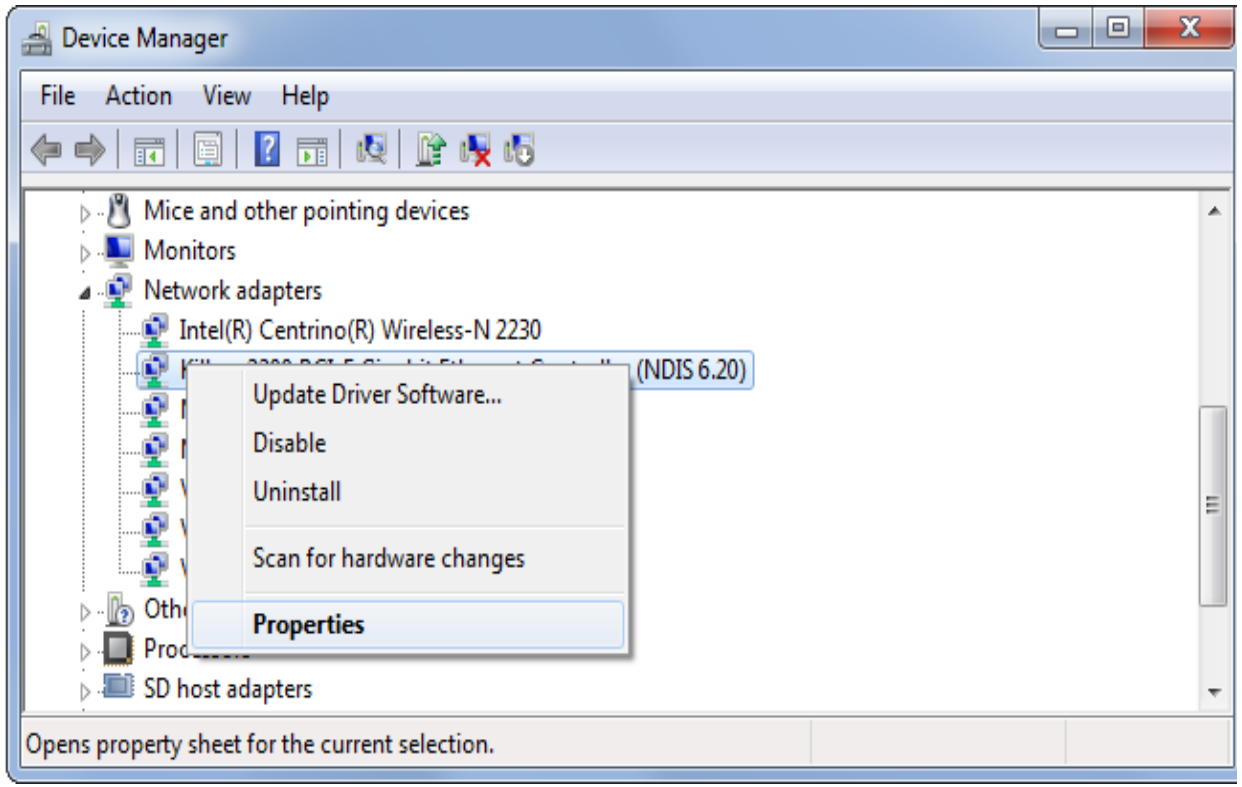
Windows

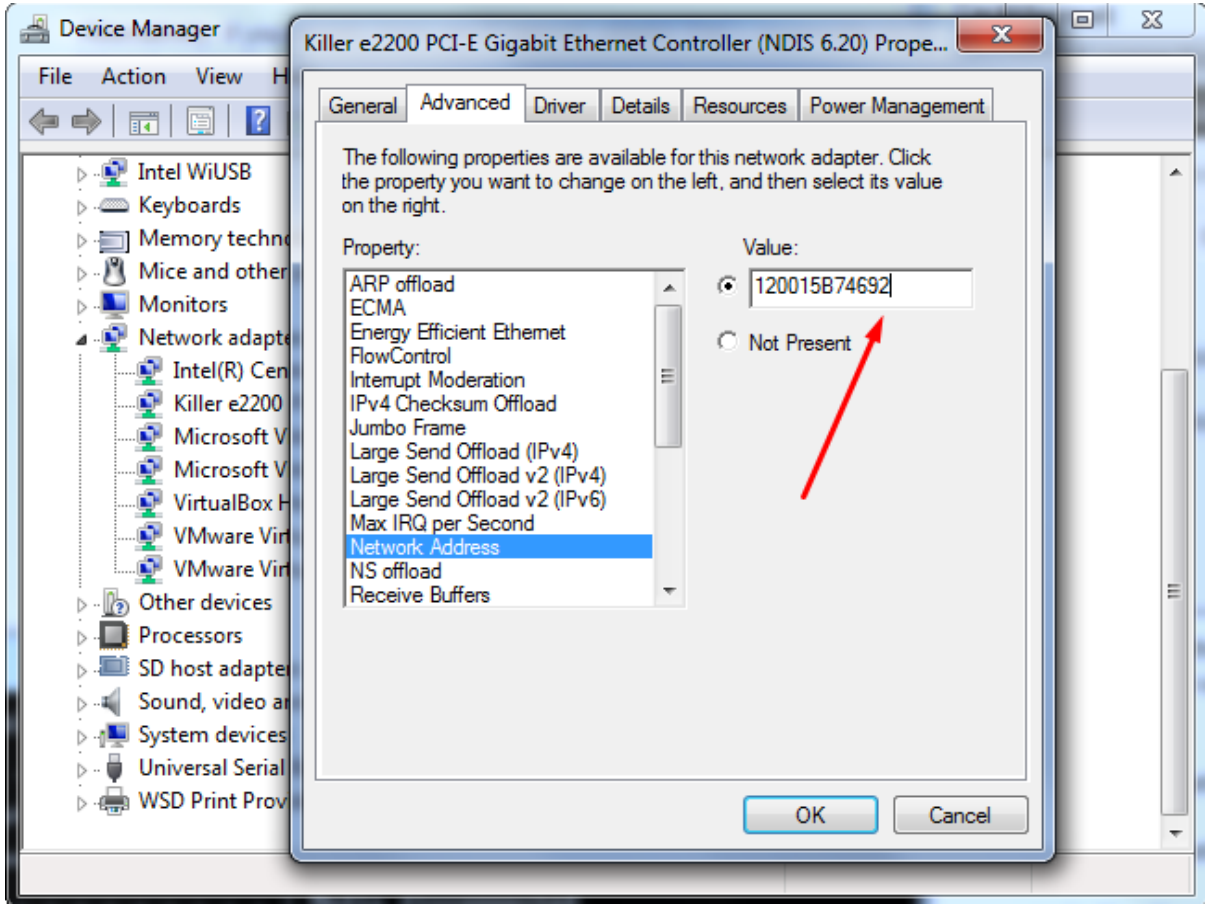


Linux

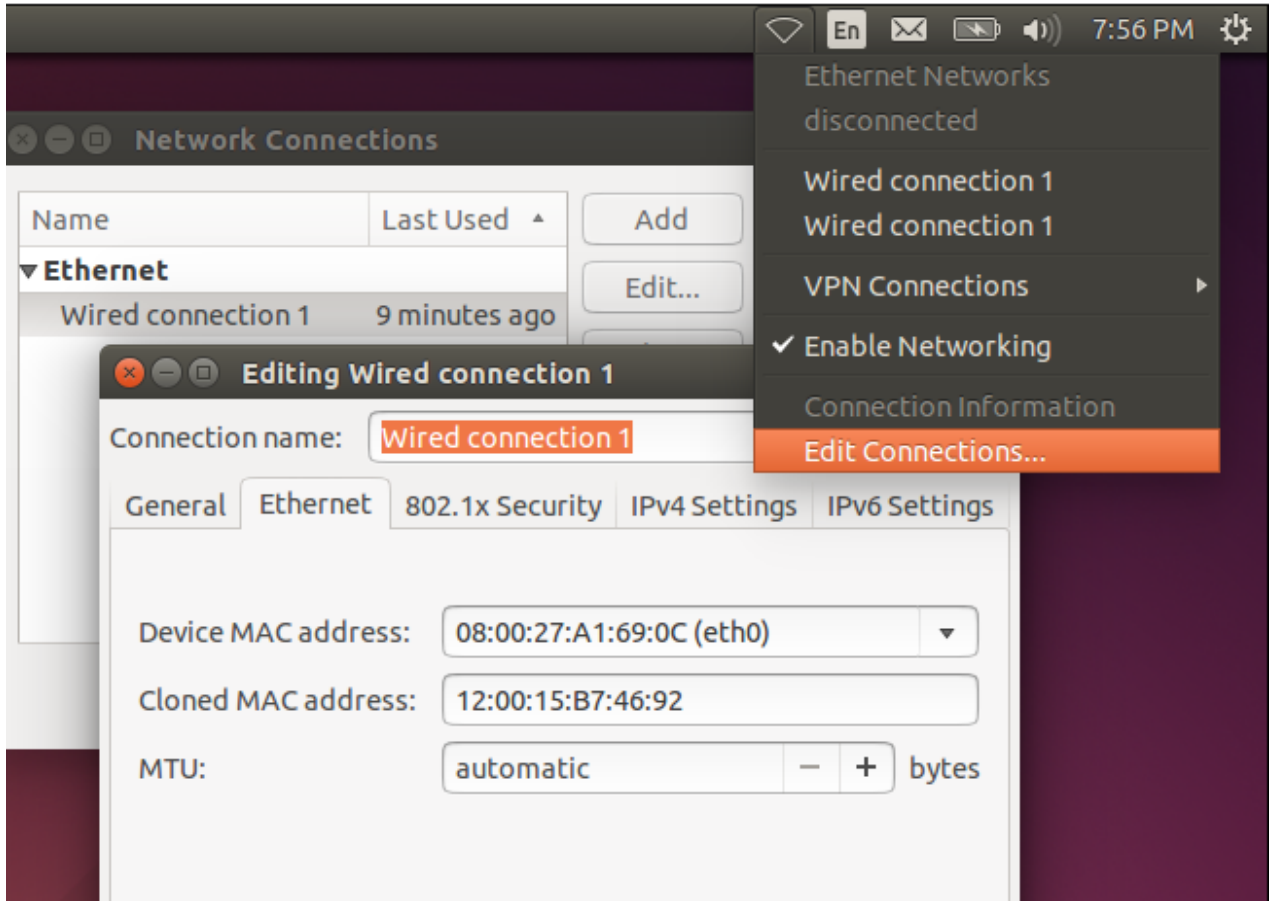


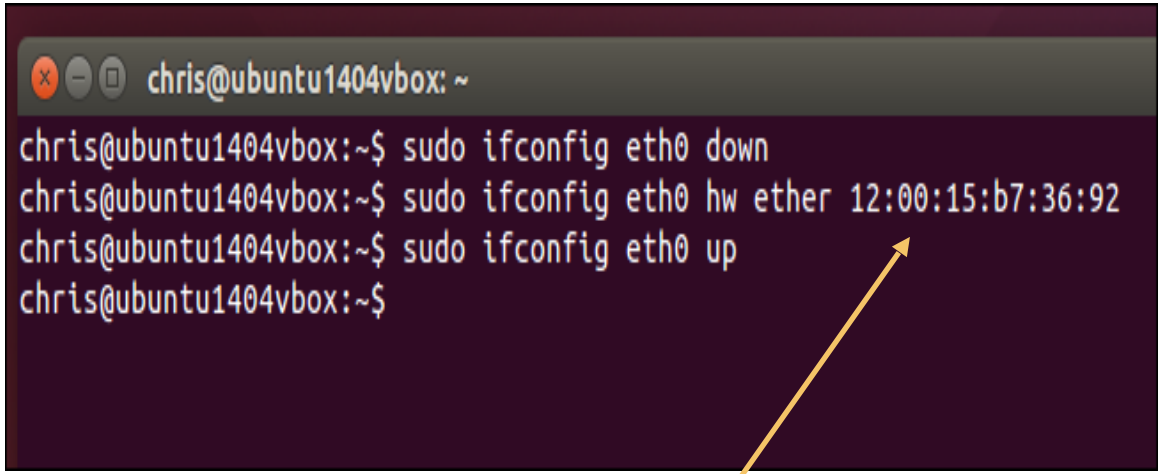
How to Modify a MAC Address in Windows



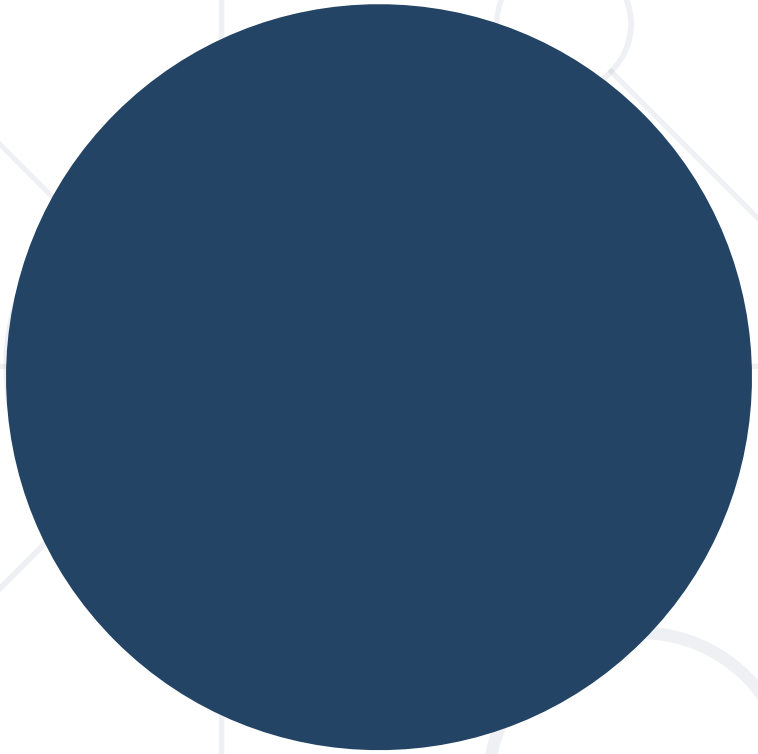


How to Modify a MAC Address in Linux



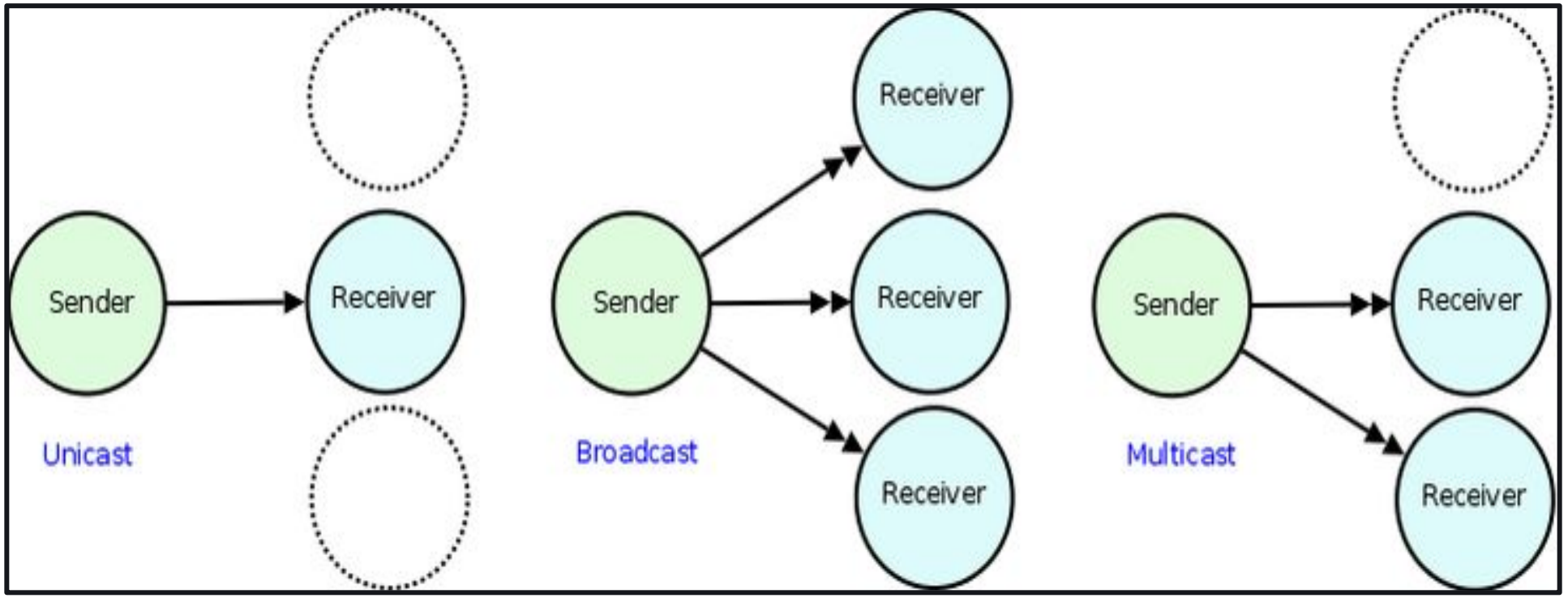


The new MAC address

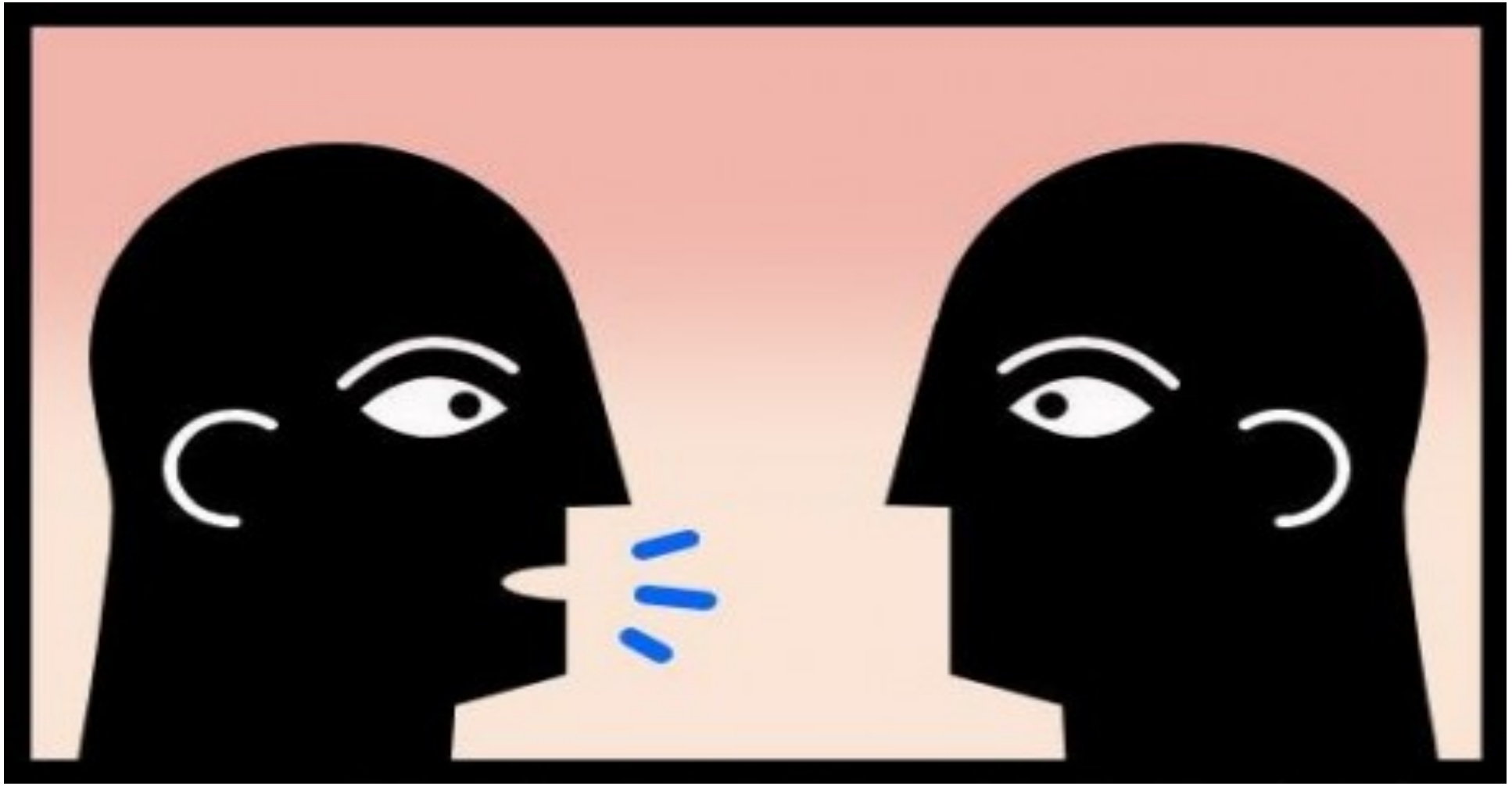


Traffic Types

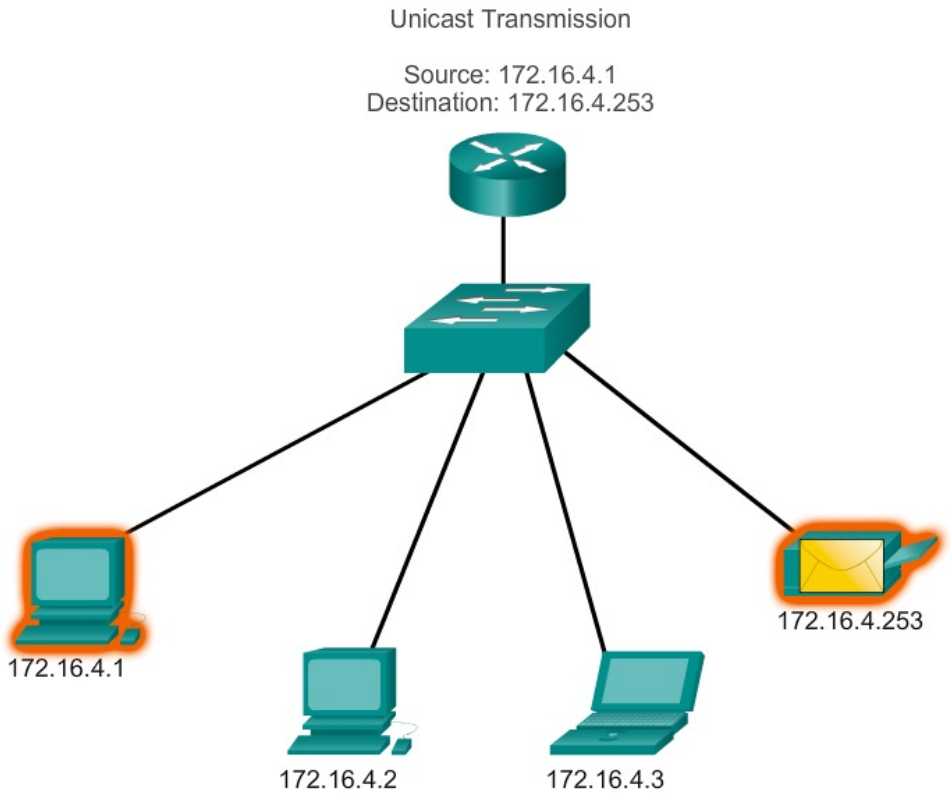
Types of traffic



Unicast



Unicast (2)

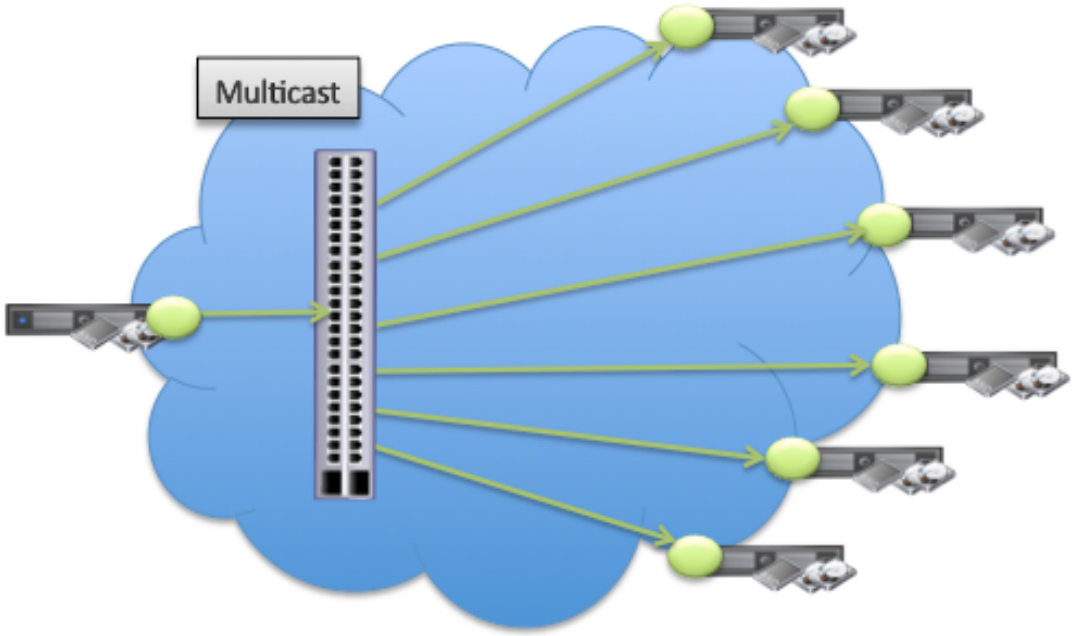


- Single destination identified by a unique address
- Used in host-to-host or host-to-server communication

Broadcast

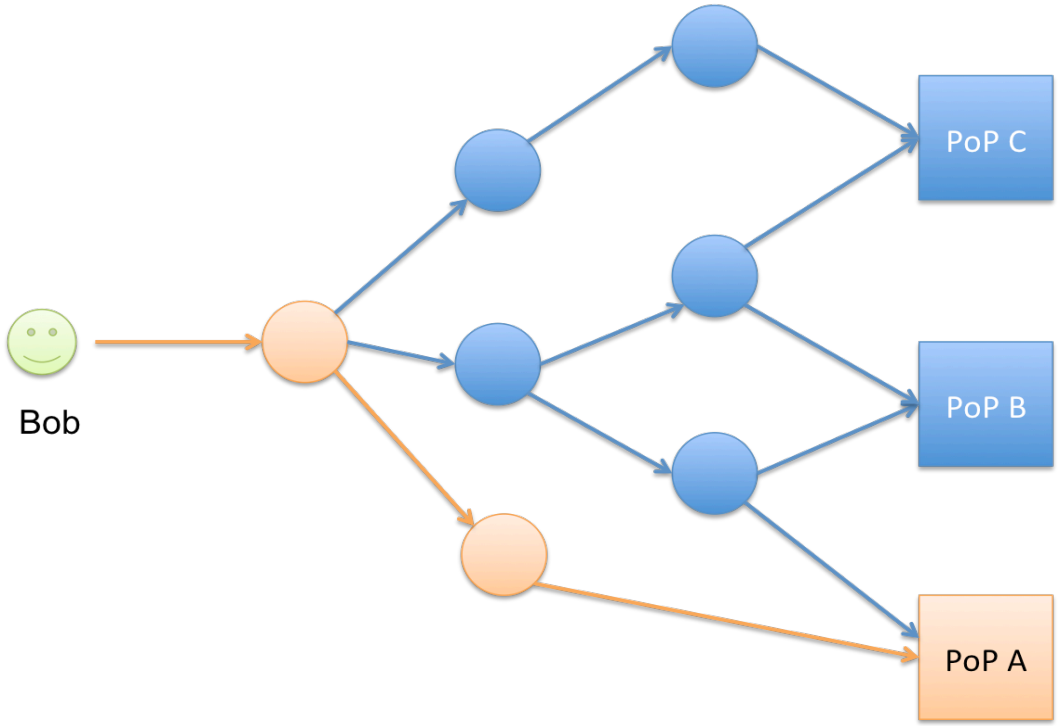
- Send a message to all recipients simultaneously
- Used in DHCP, ARP
  (will be discussed later)

Multicast

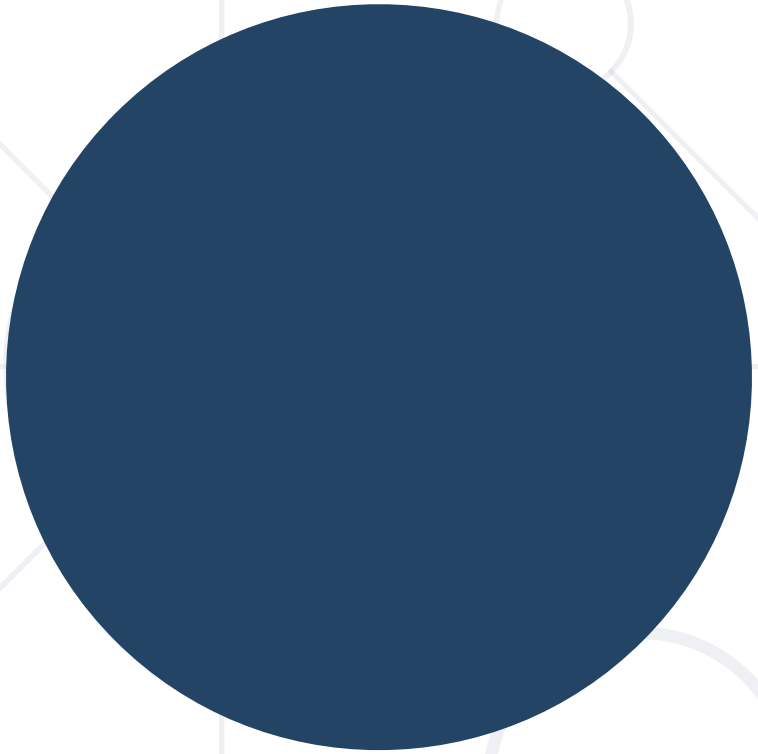


- Transmit a single message to a group of recipients
- One-to-many or many-to-many distribution
- Examples:
  - one person is talking on Skype with two other people
  - sending e-mail message to a mailing list
  - audio/video streaming

Anycast

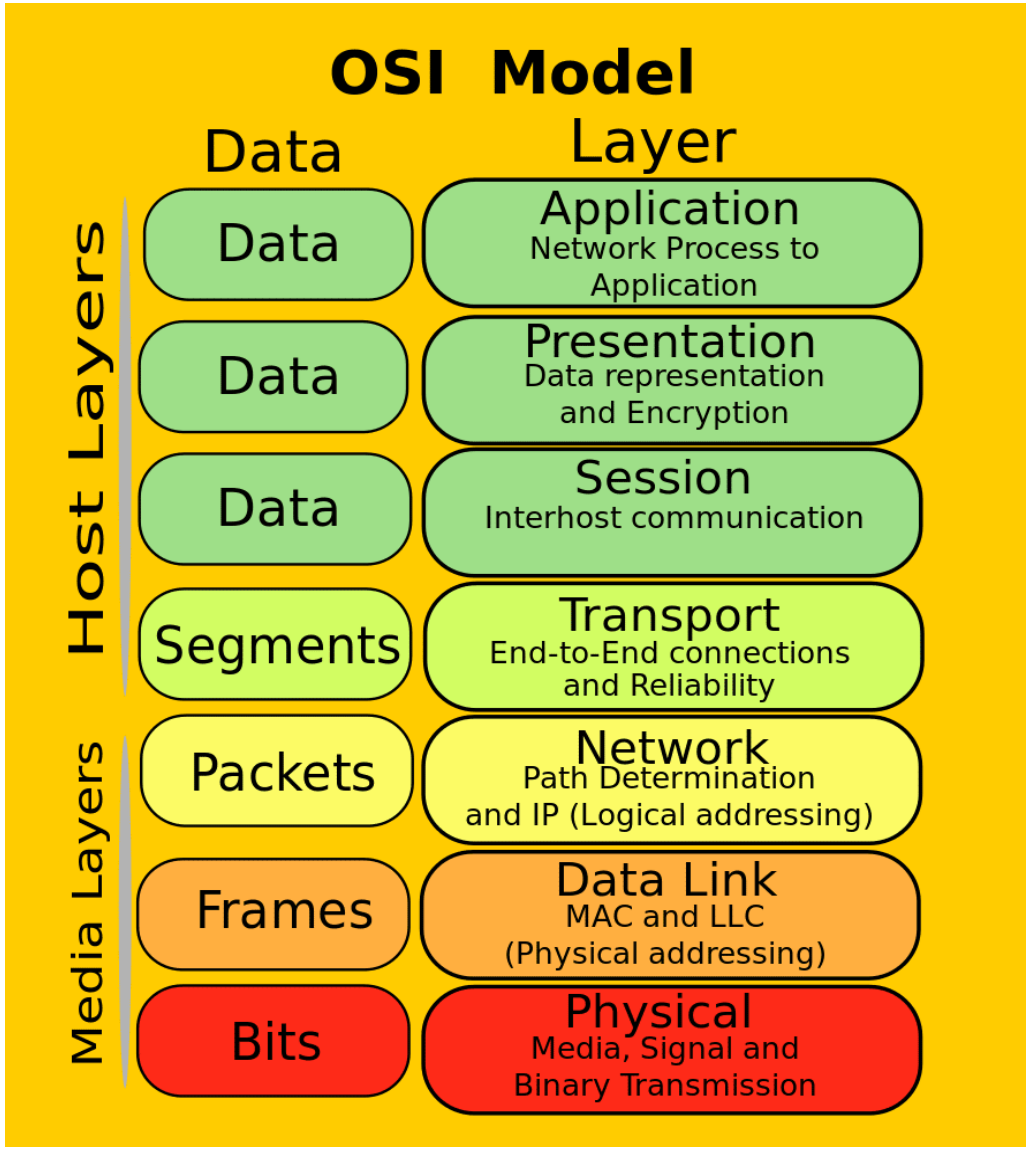


- Traffic from a single sender is routed to the nearest node in a group of potential receivers
- Advantages:
  - better speed/performance
  - enhanced reliability
- Disadvantages:
  - more difficult to implement and troubleshoot
  - not supported by all protocols



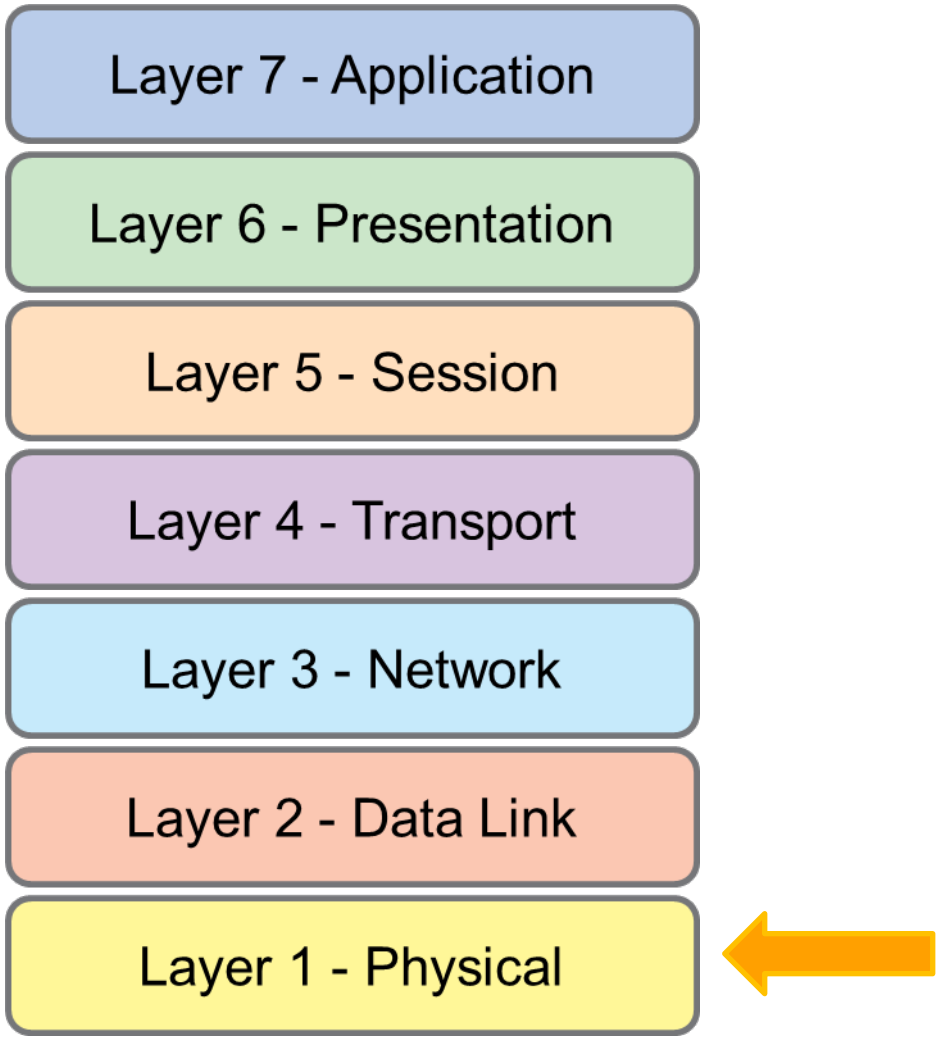
OSI and TCP/IP models

OSI Model



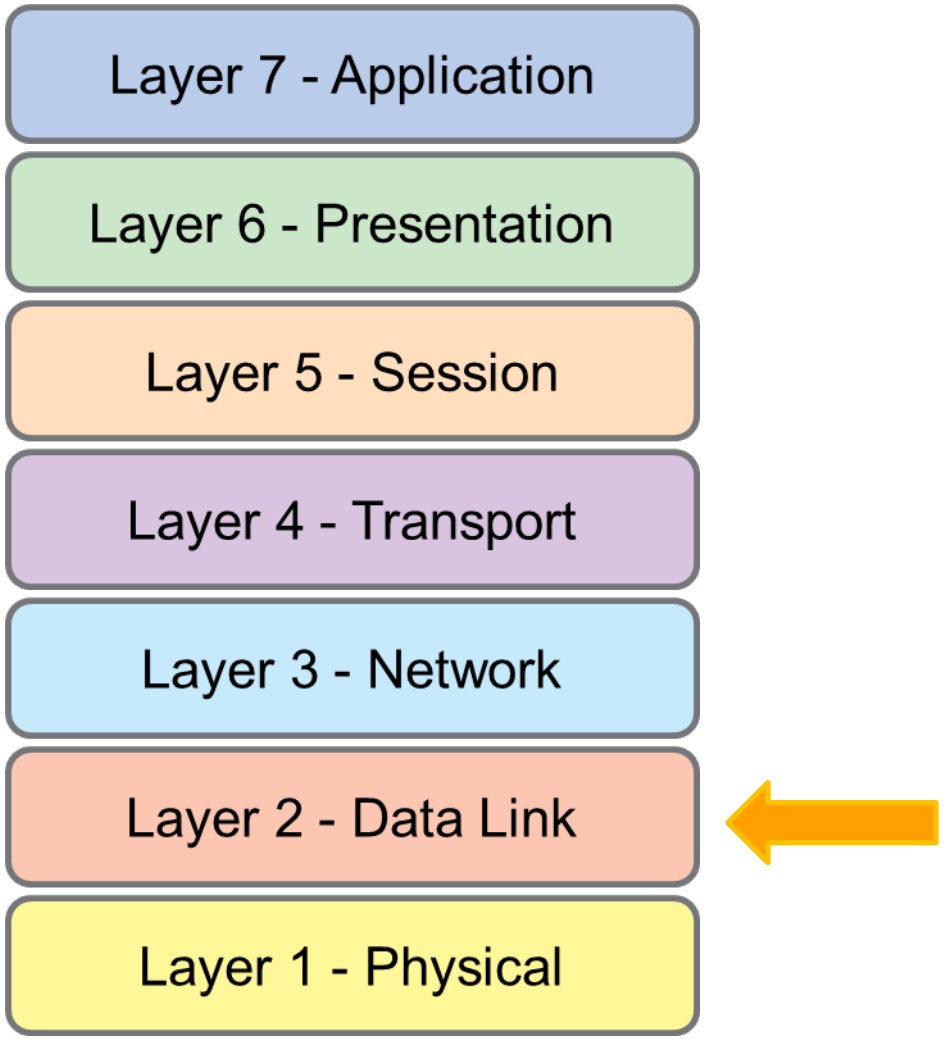
- OSI = Open Systems Interconnection
- Why?
  - Organizes the information
  - Simplifies learning
  - Standards for the vendors
  - Easier troubleshooting
- Protocol Data Unit (PDU) – different data format at each layer

Layer 1 - Physical



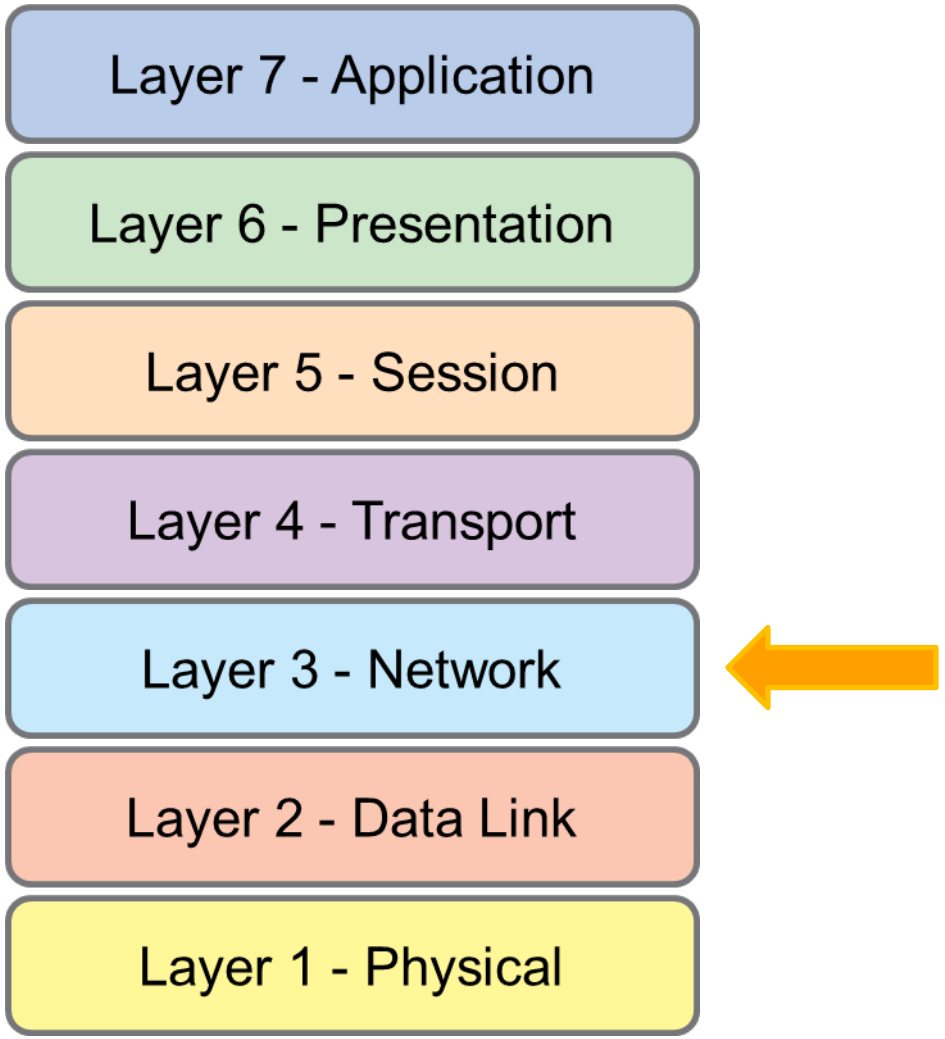
- The first and lowest layer
- Transmitting raw bits
- Wiring standards
- Devices: hubs, repeaters, modems, cabling, connectors
- Protocols: USB, Infrared, Bluetooth

Layer 2 – Data Link



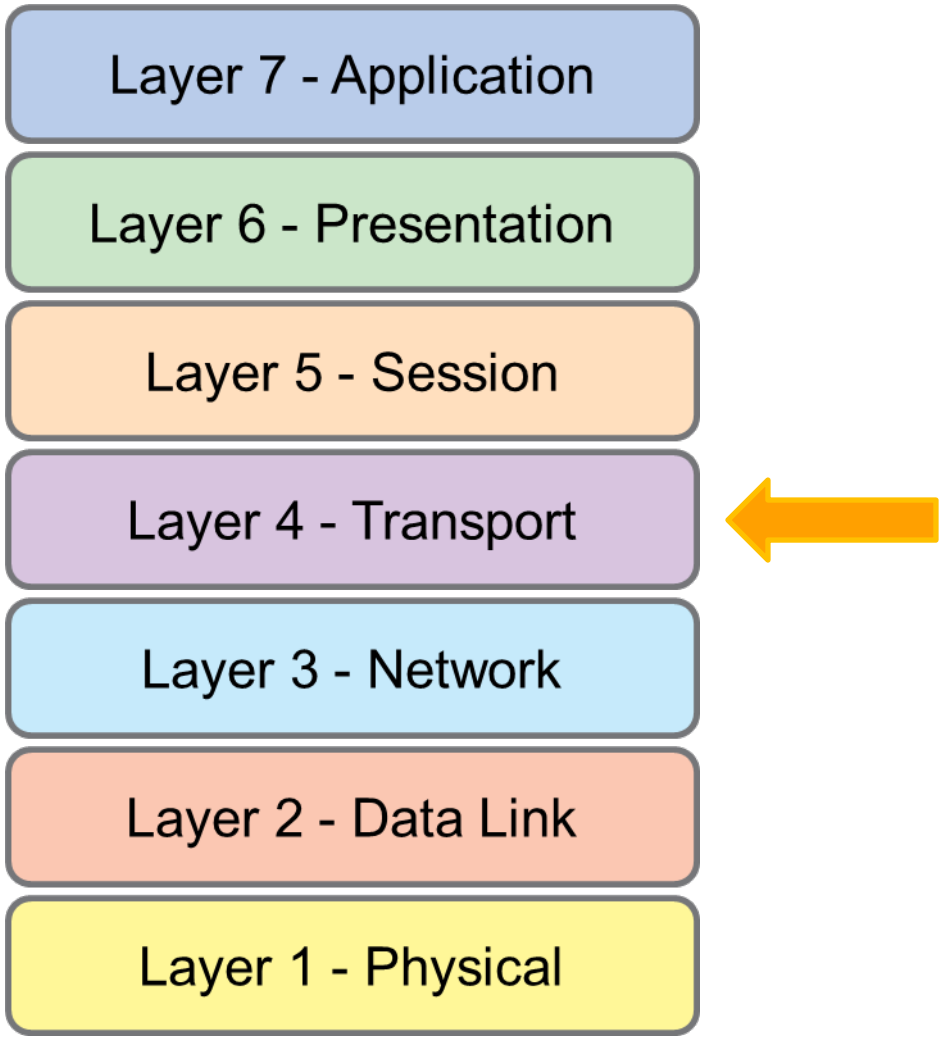
- Switching functions
- MAC addresses
- Devices: switch, bridge, NIC
- Protocols: VLAN, ARP, LLDP, CDP, STP

Layer 3 – Network



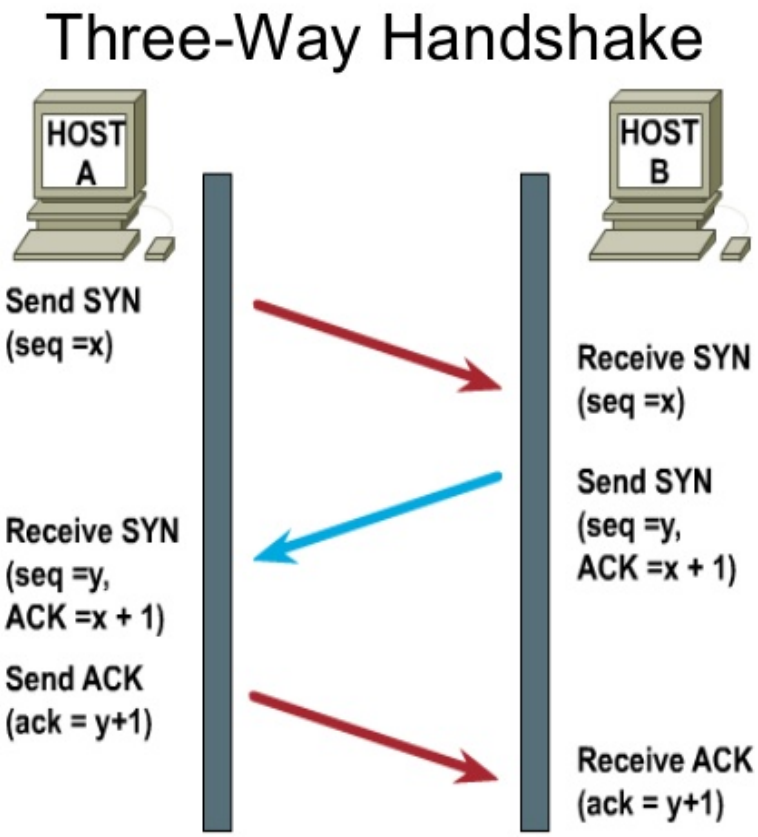
- Routing functions
- IP addresses
- Devices: router, L3 switch
- Protocols: IP, ICMP (ping), RIP, OSPF, EIGRP, GRE, etc.

Layer 4 – Transport



- Provides “host-to-host communication”
- Services:
  - connection-oriented vs connection-less
  - reliability (ACK, NACK)
  - flow control
  - multiplexing (port numbers)
- Protocols: TCP, UDP

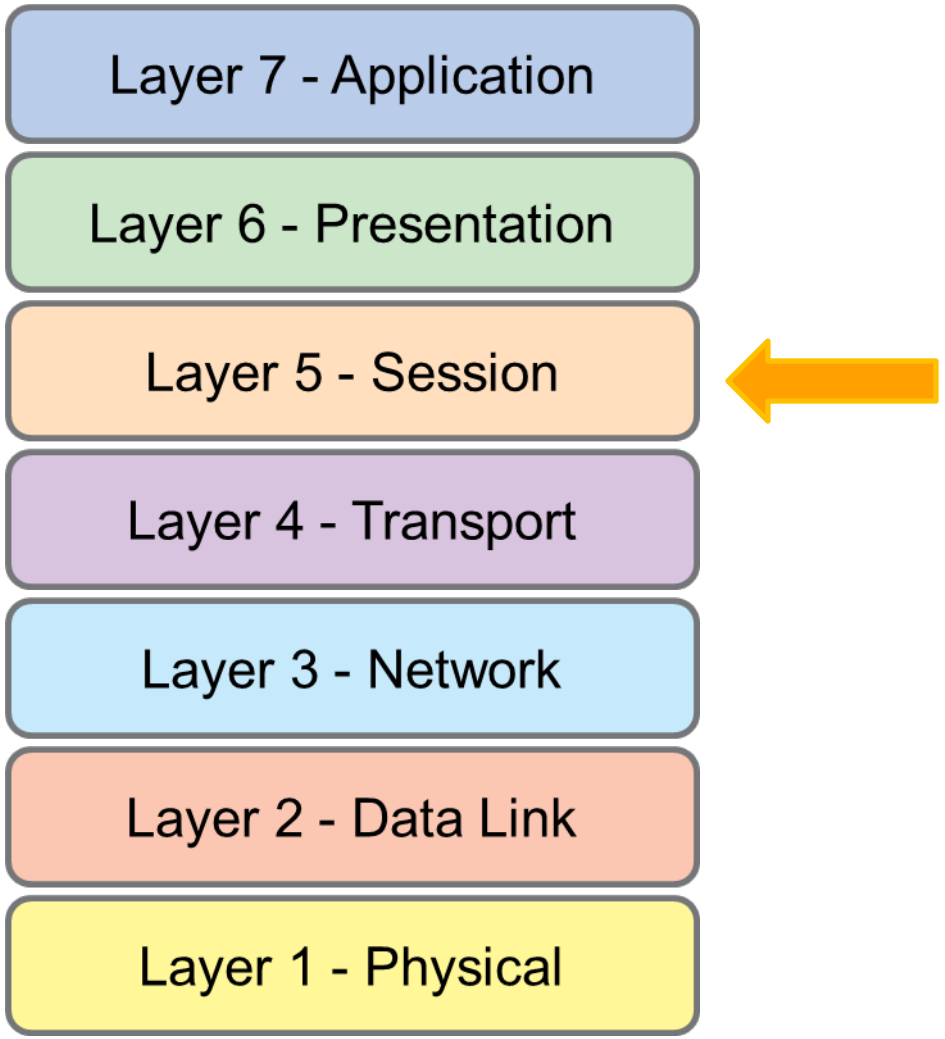
TCP Three-Way Handshake



- This is how TCP creates a connection over an IP network
- a.k.a. “SYN, SYN-ACK, ACK” handshake

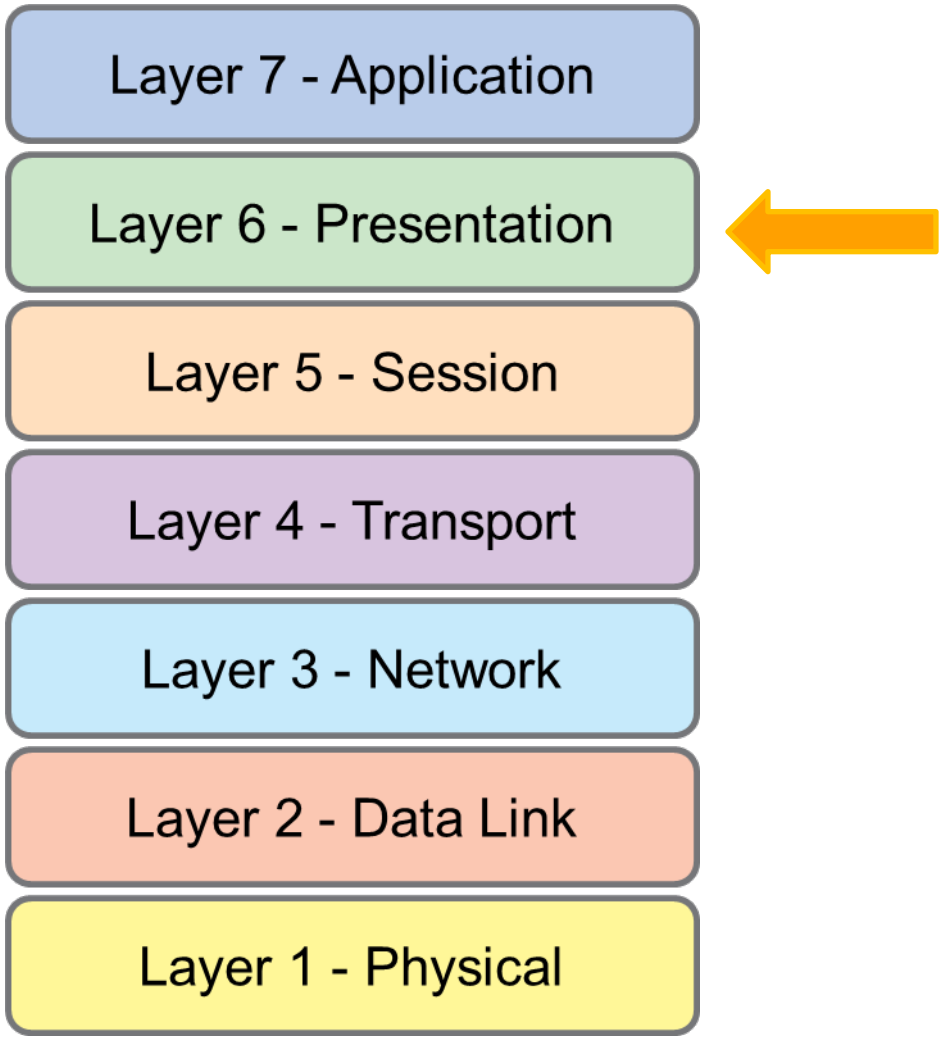
TCP/UDP Twitter joke

Layer 5 – Session



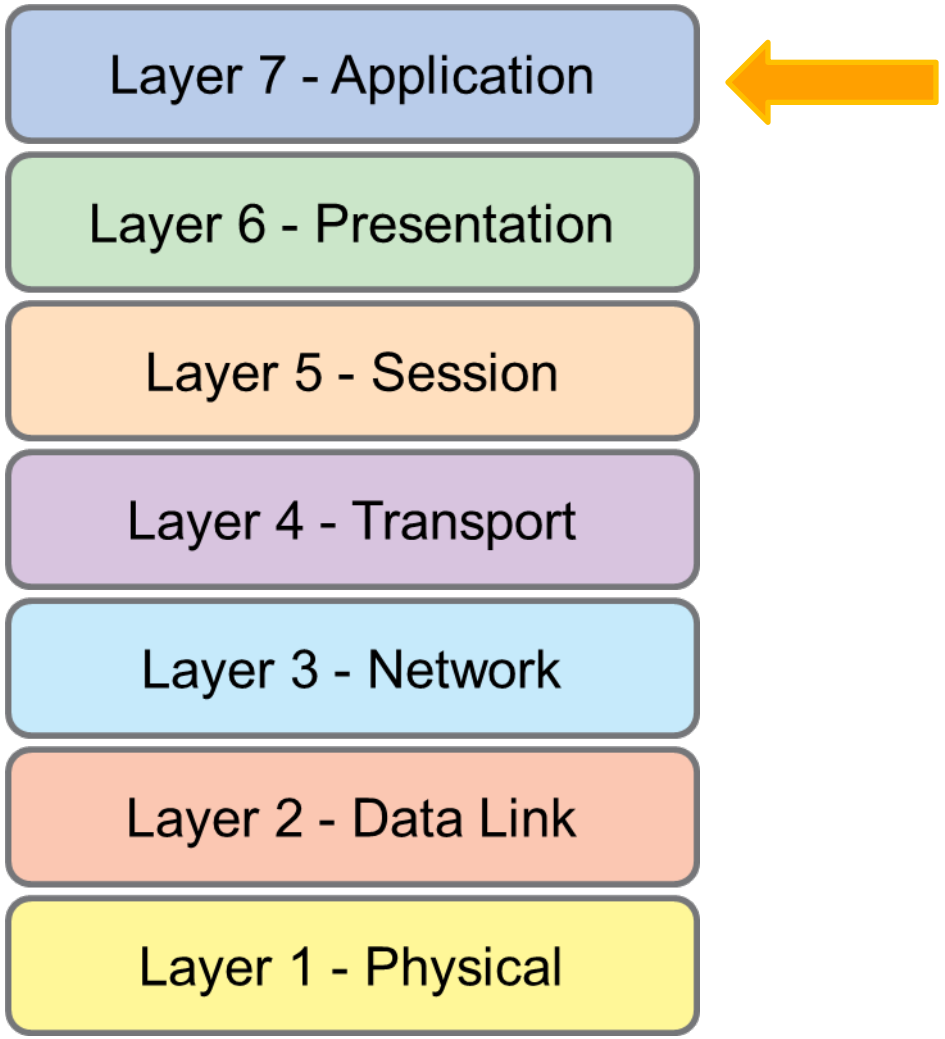
- Opening, closing and managing a session
- Services:
  - Authentication
  - Authorization
  - Session restoration
- Protocols: PPTP, L2TP, NetBIOS, RPC

Layer 6 – Presentation



- Sometimes called syntax layer
- Acts as data translator for the network
- Services:
  - data conversion
  - compression
  - encryption/decryption

Layer 7 – Application



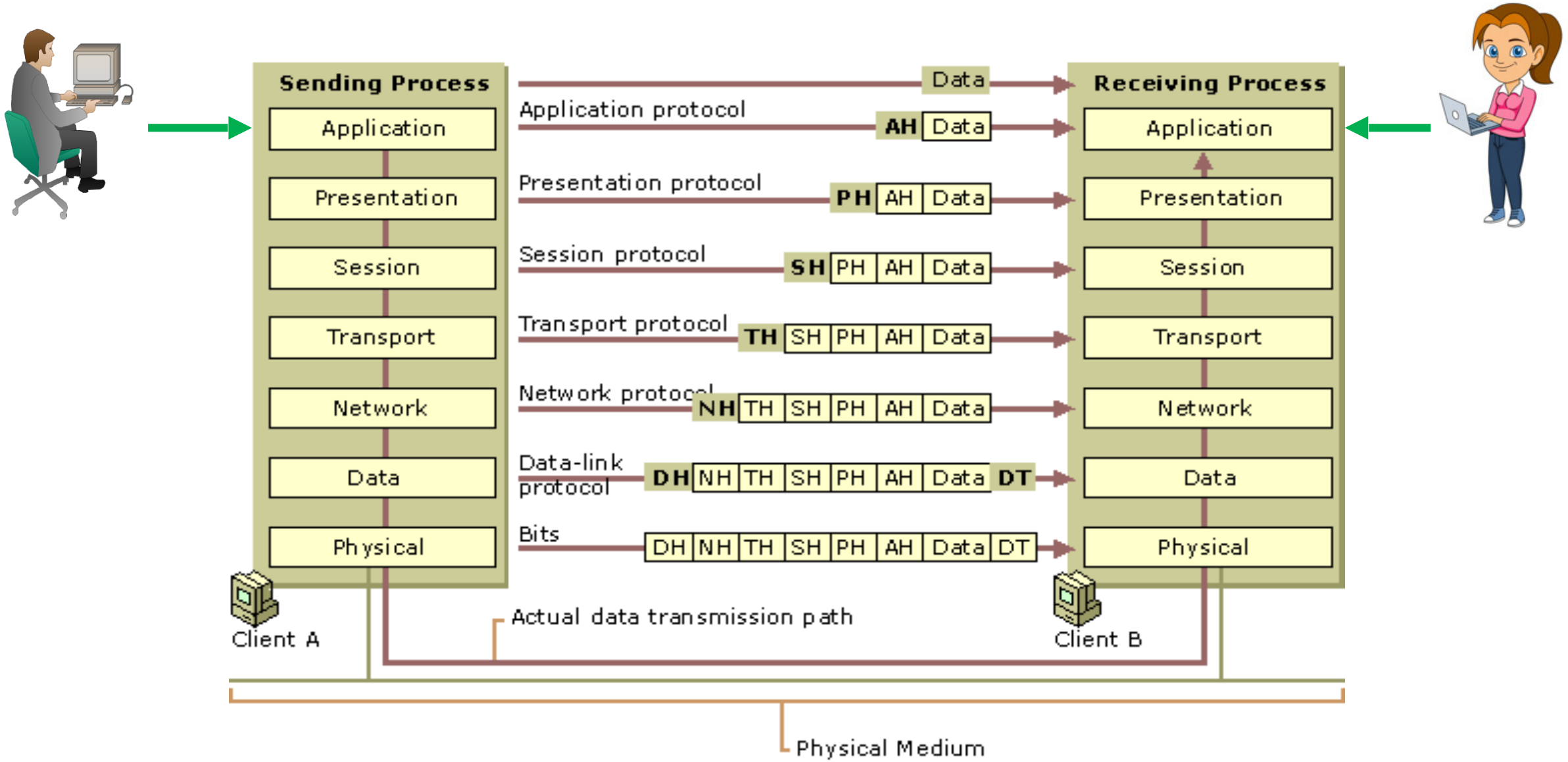
- End-user interaction with the network
- Protocols: HTTP(s), FTP, SMTP, Telnet, SSH, RDP

Mnemonics for the OSI Model

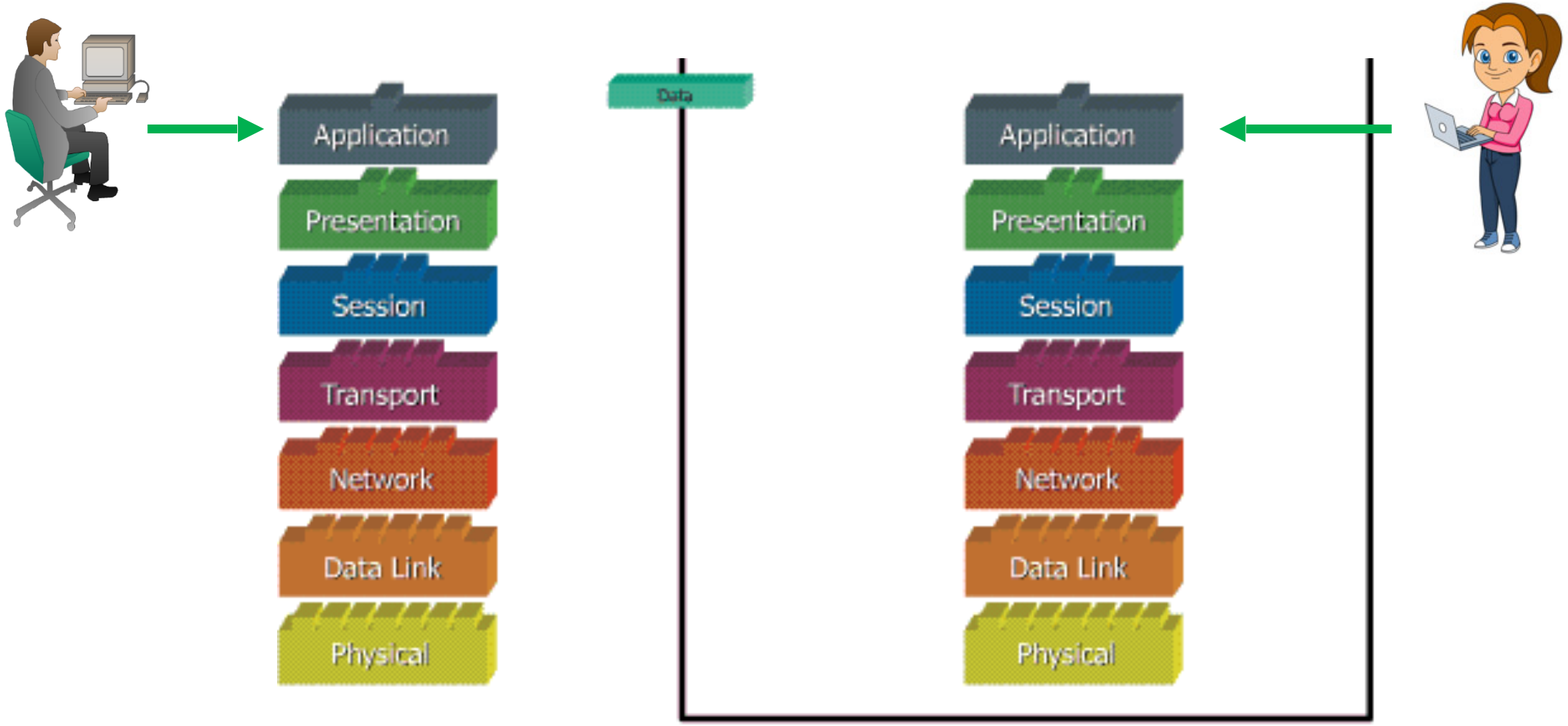
All
People
Seem
To
Need
Data
Processing

Away
Pizza
Sausage
Throw
Not
Do
Please

Data Flow in the OSI Model

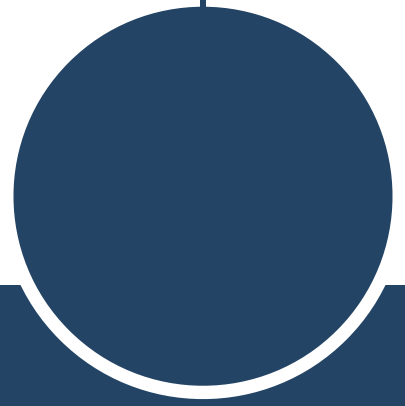


Data Flow in the OSI Model (2)

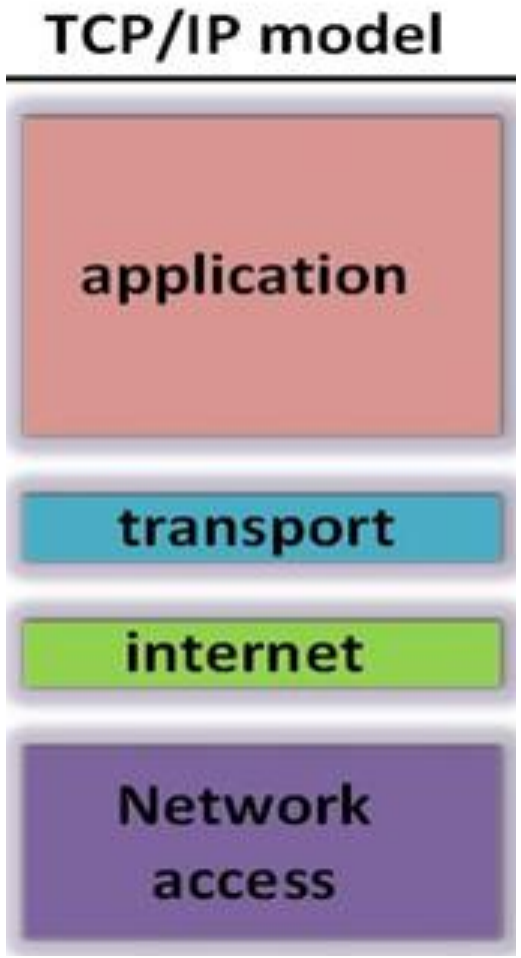


Encapsulation and decapsulation

- Encapsulation
  - Each layer adds its own header (and trailer)
  - During the process, the packet goes down through the layers
- Decapsulation
  - Each layer removes the corresponding header (and trailer)
  - During the process, the packet goes up through the layers

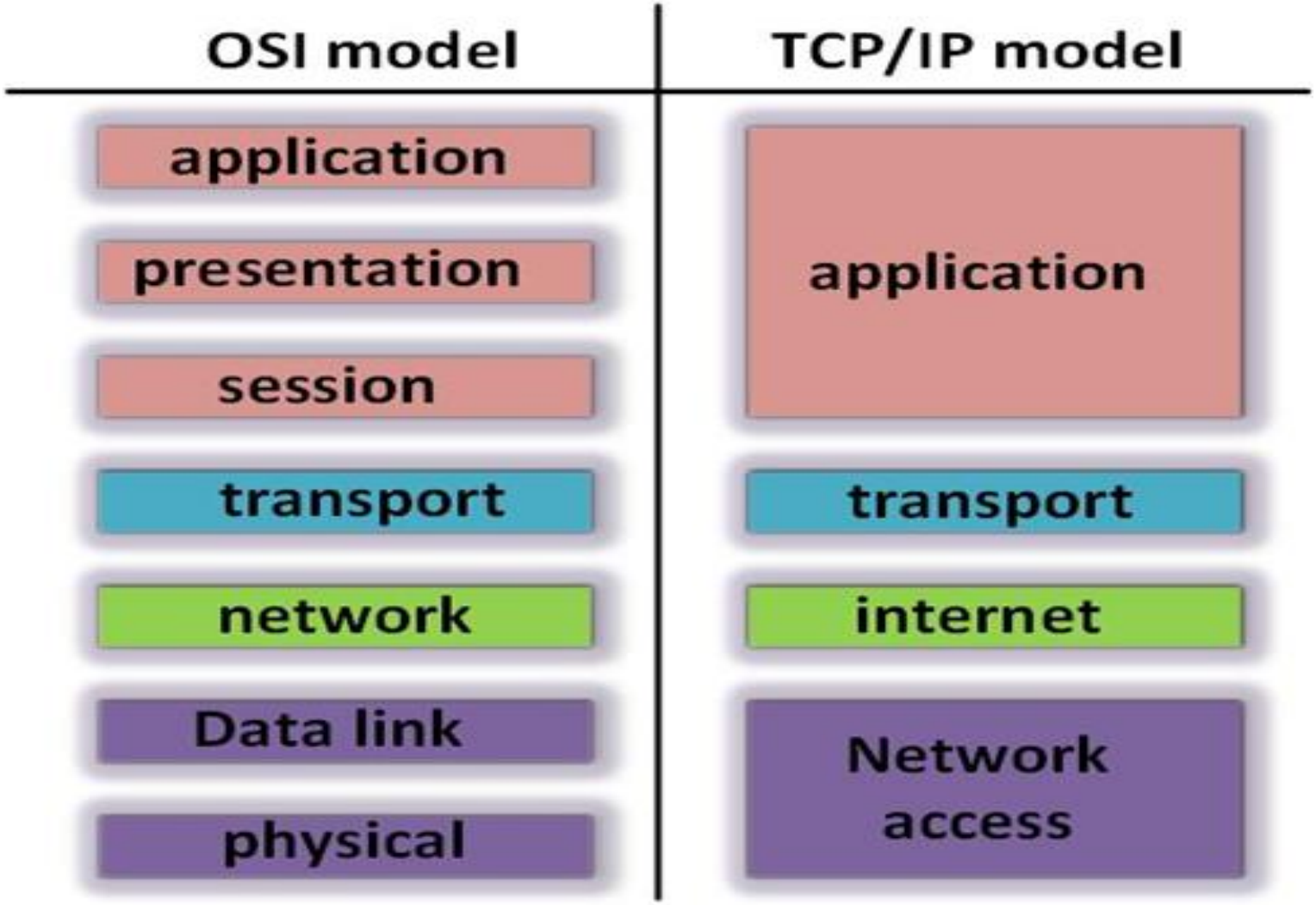


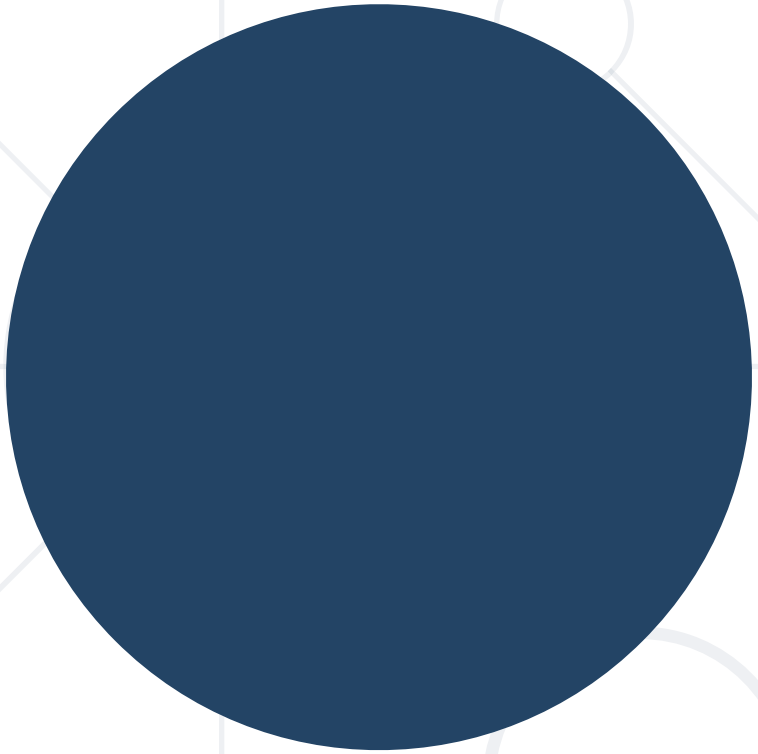
The TCP/IP Model



- Four-layer conceptual model similar to the OSI
- Known as the Department of Defense (DoD) model
- Why two models?
  - They were both created independently

OSI and TCP/IP Models Comparing





Cisco Packet Tracer - Introduction

DEMO

Summary

1. Basic networking concepts
2. IP and MAC addresses
3. Traffic types
4. OSI and TCP/IP models
5. Cisco Packet Tracer – Introduction