

# Introduction to Networking

## Lecture 1



**SoftUni Team**

**Technical Trainers**

# Questions



**sli.do**  
**#CNF**

# Table of Contents

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?

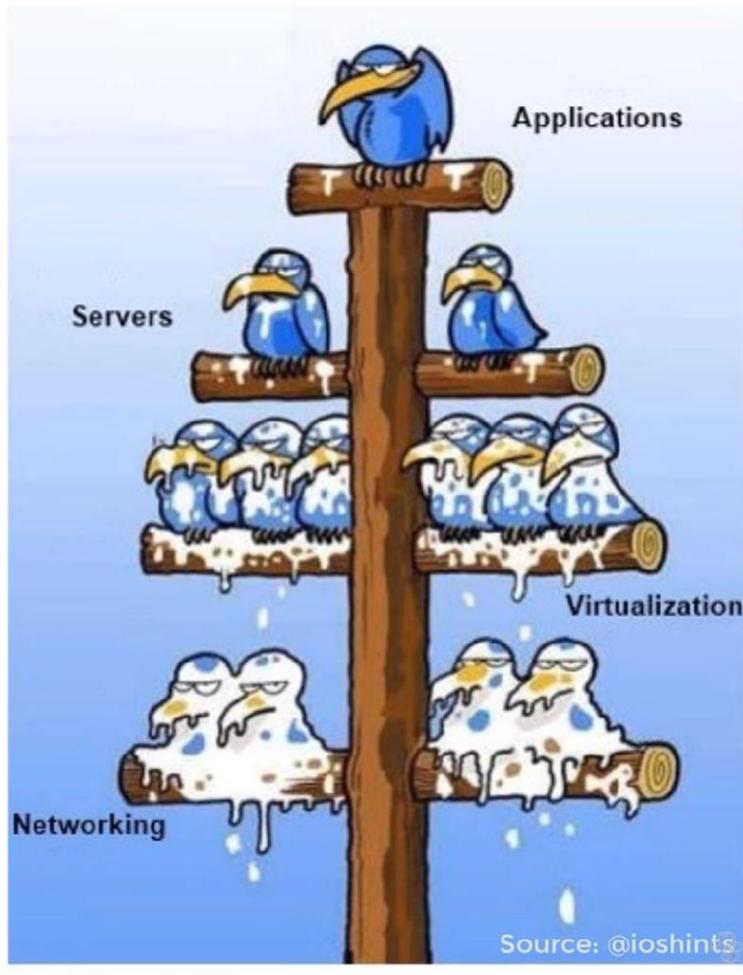


- Multiple computers linked together
- Why? To communicate and share resources

# 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

# Why computer networking is important

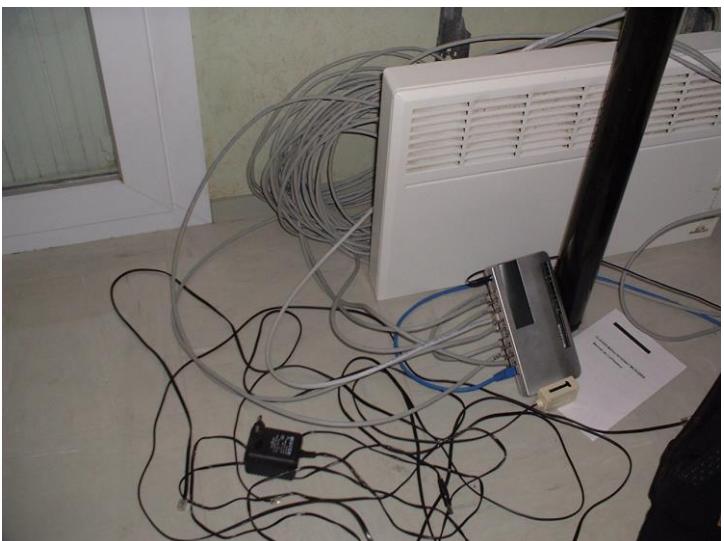


- Services, consumed by the users, depend on computer networks
- Can be ungrateful and “dirty”
  - when it works: “You are doing nothing!”
  - when it doesn’t work: “It is down again!”

# Common Types of Computer Networks

- Local Area Network (LAN)
- Wide Area Network (WAN)
- Wireless Local Area Network (WLAN)
- Storage Area Network (SAN)
- Internet of Things (IoT)

# Local Area Network (LAN)



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

# Wide Area Network (WAN)

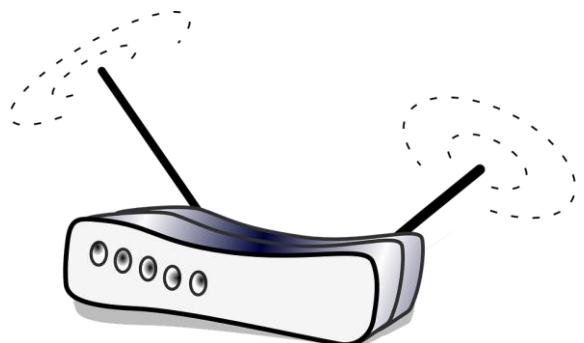


- Connects multiple LANs together
- Extends over a large geographical distance
- The **Internet** is the largest WAN spanning the Earth

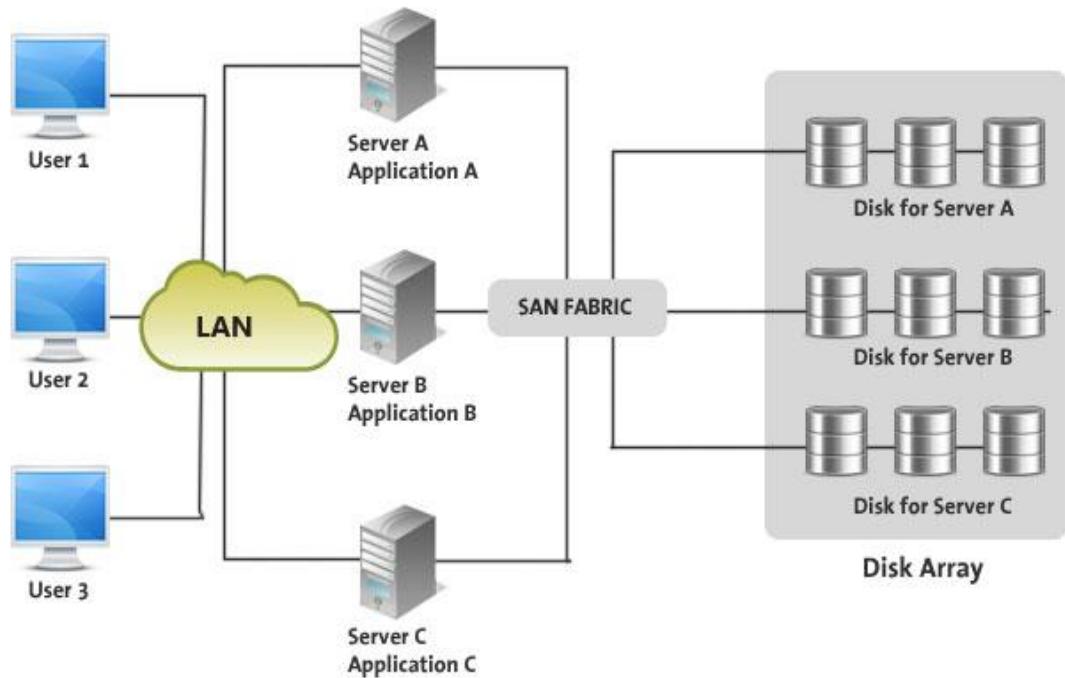
# Wireless Local Area Network (WLAN)



- 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)

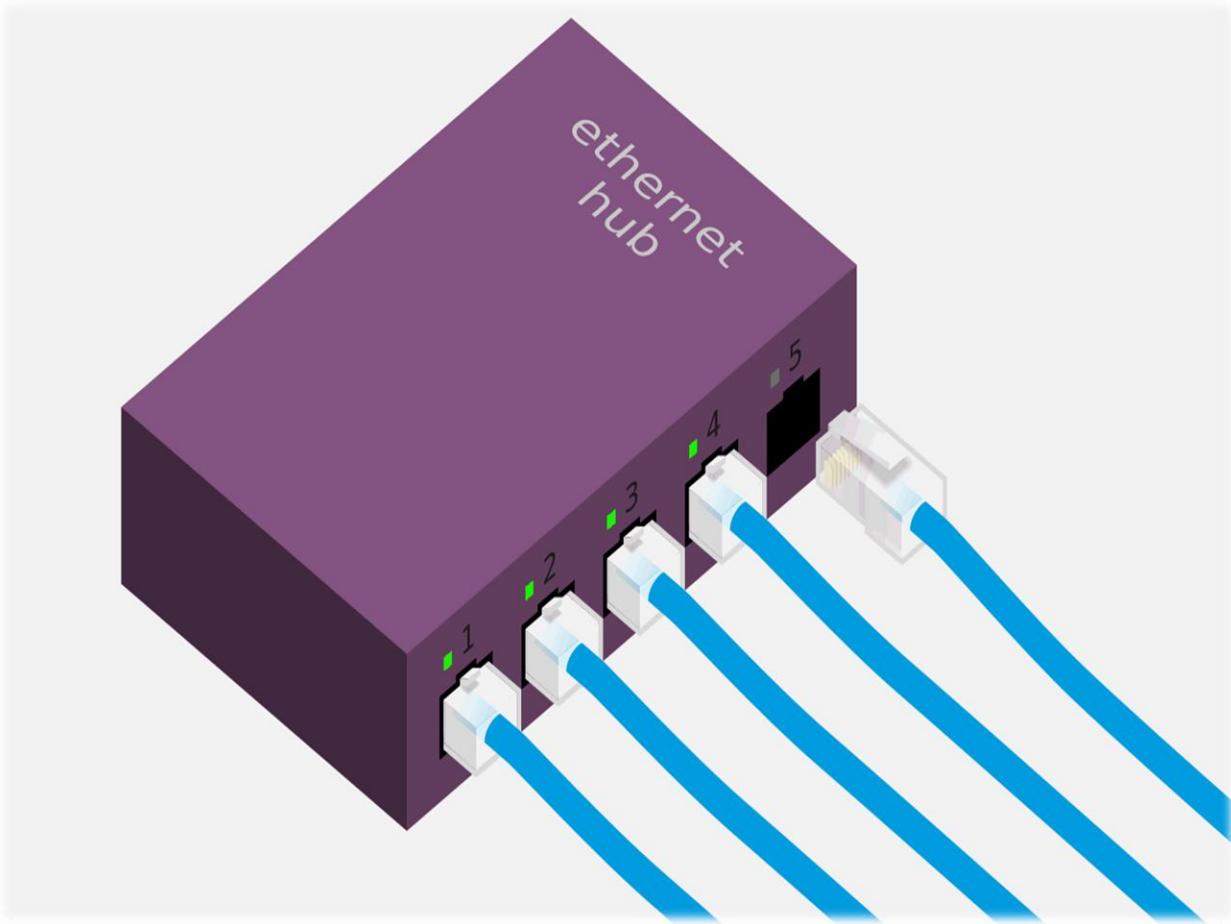
# Internet of Things (IoT)



# Common Types of Networking Devices

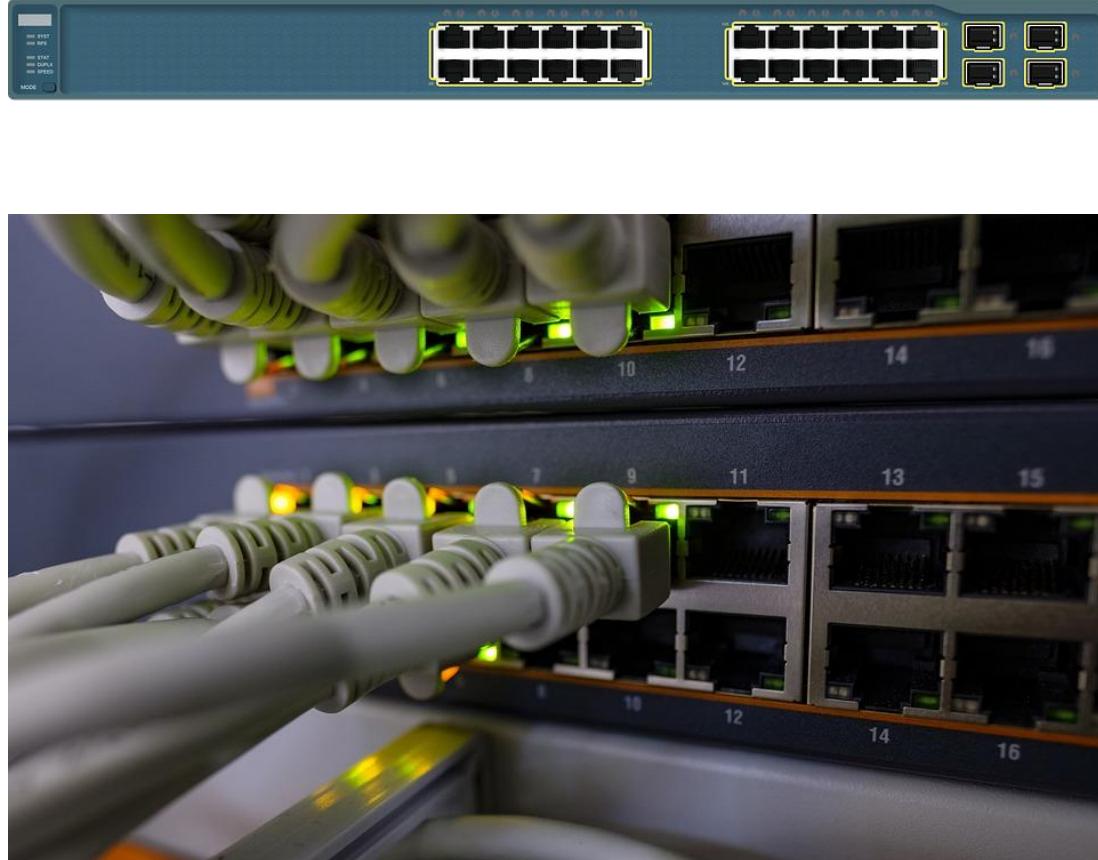
- Hub (obsolete, not secure and very slow)
- Switch
- Router
- Modem
- Firewall
- Bridge (like a Switch, fewer ports)
- Repeater (like a Hub, it just amplifies the signal)
- Access point

# 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



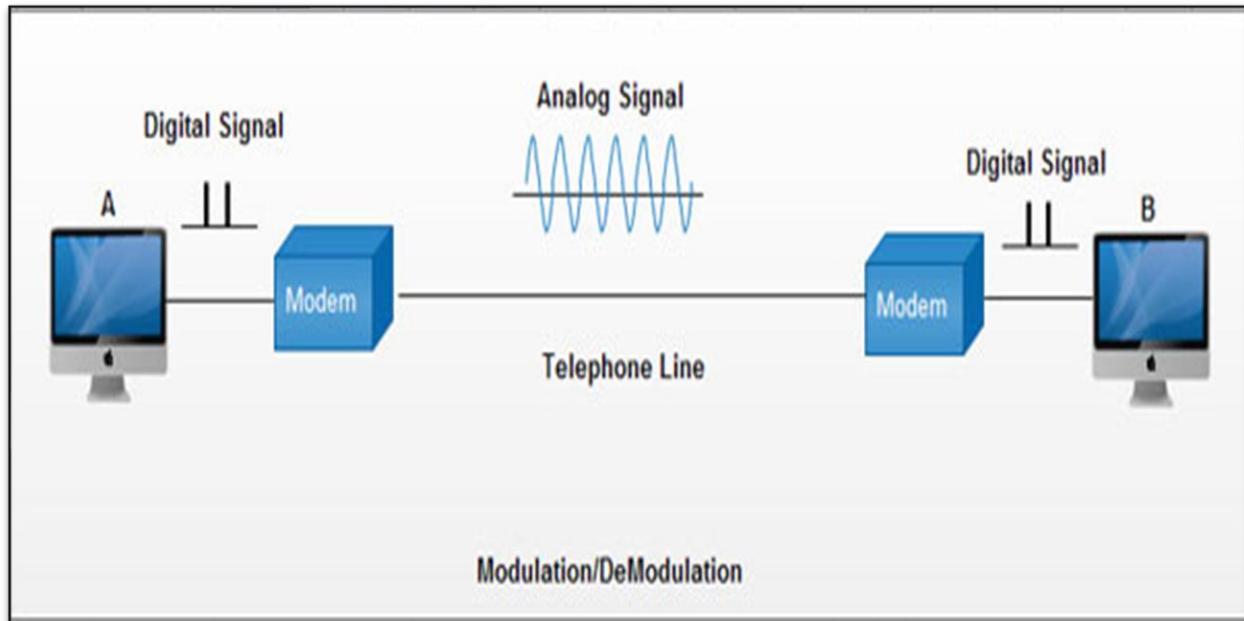
- Provides end user connectivity
- More intelligent than a hub
- Has a MAC address table
- Provides Layer 2 functionality (and optionally L3)
- VLANs can be configured

# Router



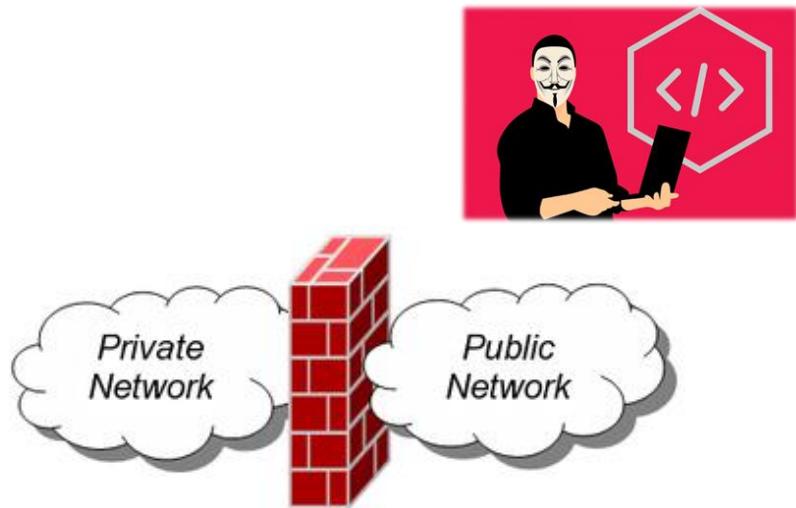
- Sends packets from one network to another
- Provides **Layer 3** functionality
- Uses IP addresses to transfer packets
- “Traffic police” - directs the network traffic to different destinations

# 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

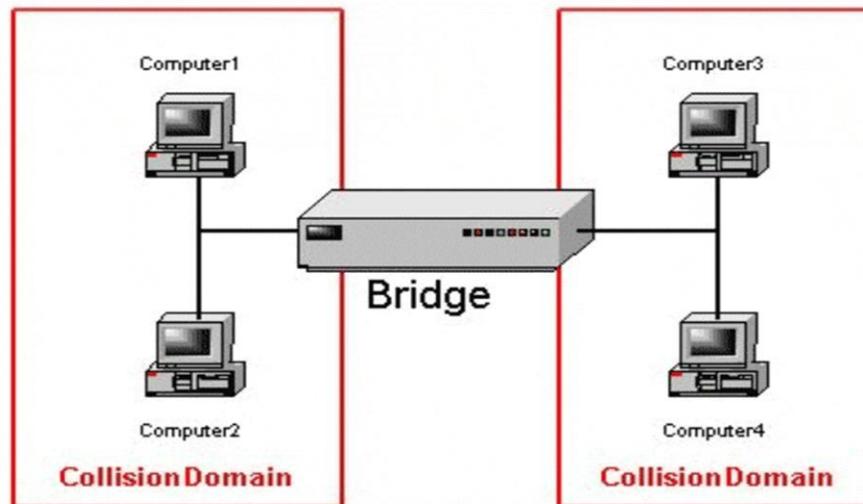
# Firewall (2)



# Bridge and repeater (obsolete devices)

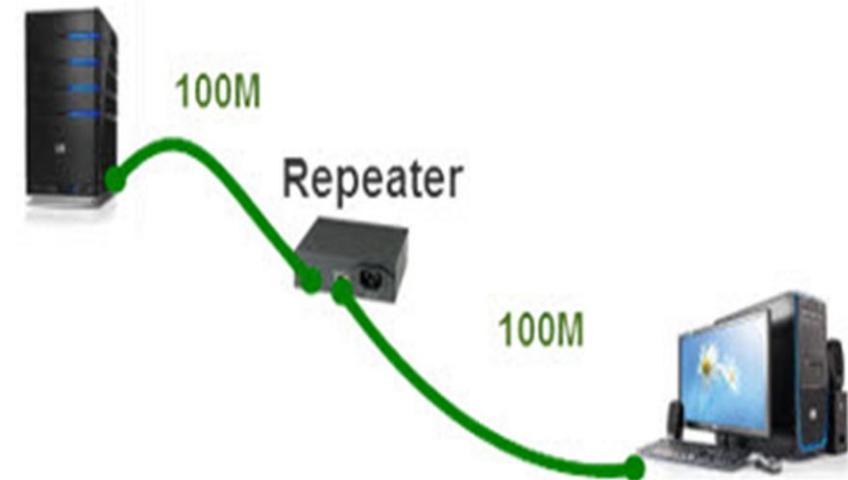
## Bridge

- Similar to a Switch
- Works at Layer 2



## Repeater

- Similar to a Hub
- Works at Layer 1

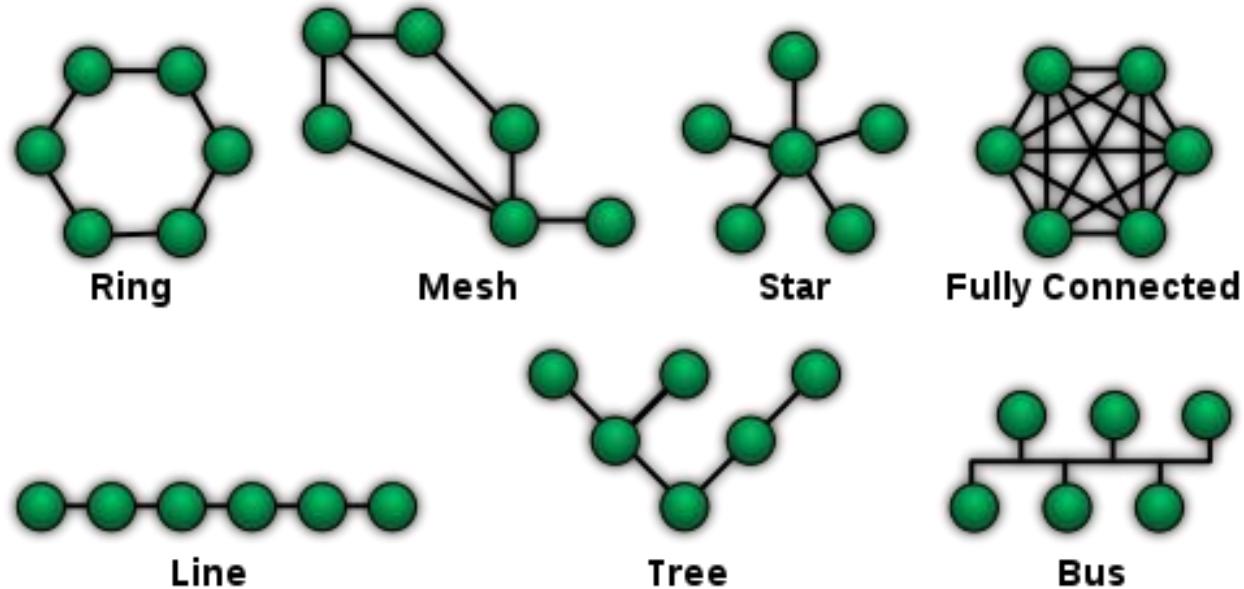


# Access point



- Provides wireless access to the (wired) network
- Commonly used in homes, businesses, and public areas
- Main challenges – security and speed
- Can be a standalone device or integrated into a router, for example

# Types of Network Topologies



- Star is the most common topology
- Hybrid topologies
- Physical vs logical topologies

# What is a (network) protocol?

- Protocol: A general term, typically defining a system of rules and acceptable behavior
- Can be used in politics, diplomacy, science, medicine, etc.

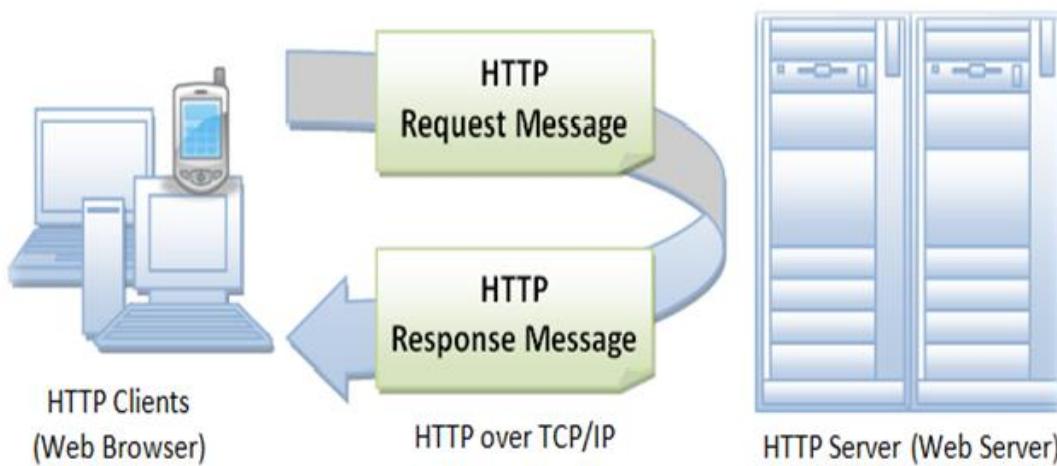
## What is a network protocol?



In networking, a protocol is a set of rules for formatting and processing data. Network protocols are like a common language for computers. The computers within a network may use vastly different software and hardware; however, the use of protocols enables them to communicate with each other regardless.

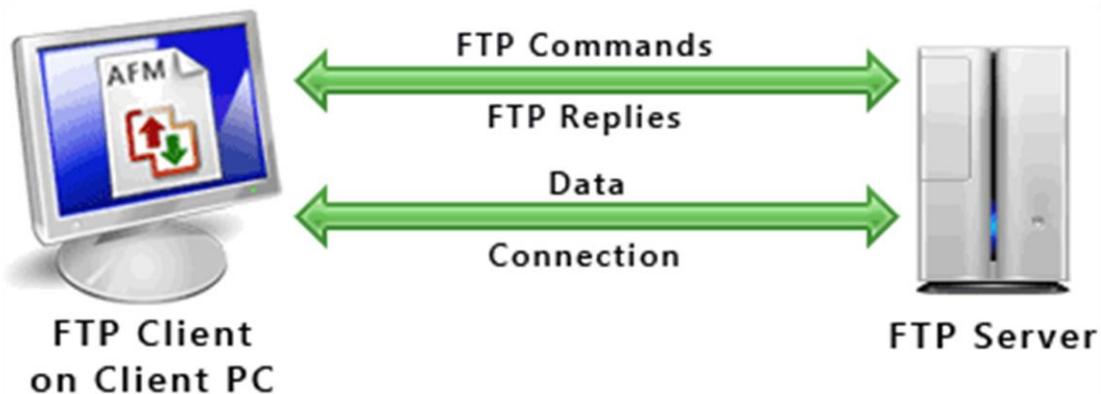


# Hyper text transfer protocol (HTTP)



- 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)



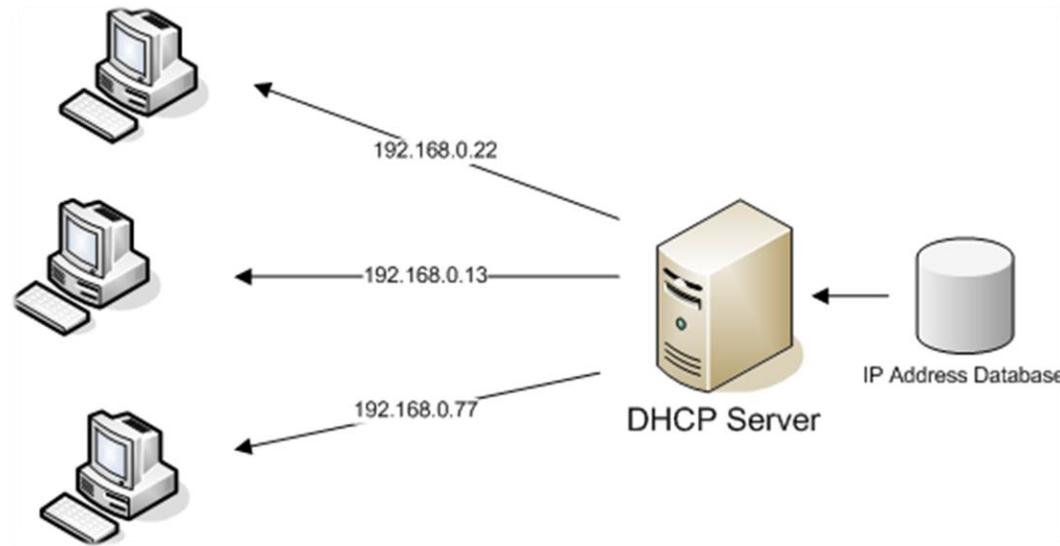
- Can be used for:
  - Server-to-server email transport
  - Client-to-server email transport

# Domain Name System (DNS)



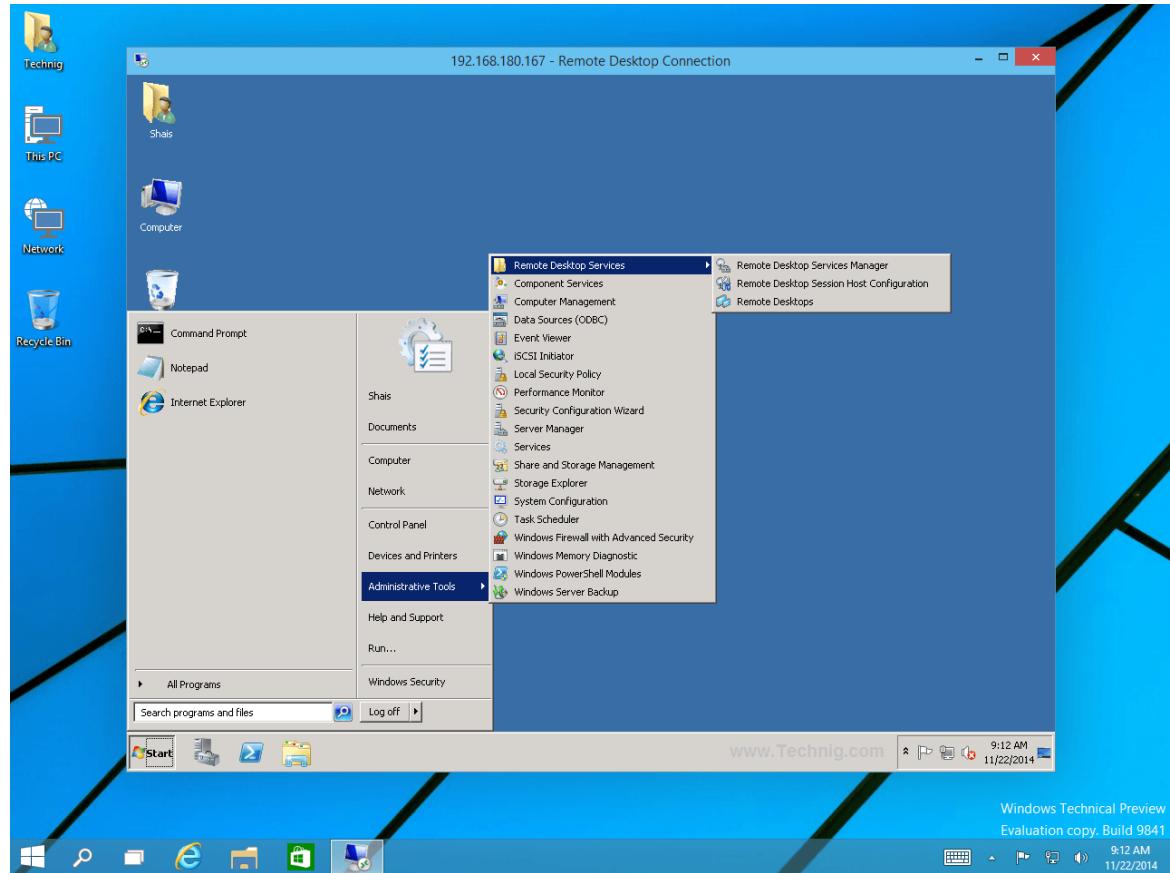
- Translates domain names into IP addresses (and much more)
- It is hierarchical and distributed database

# Dynamic Host Configuration Protocol (DHCP)



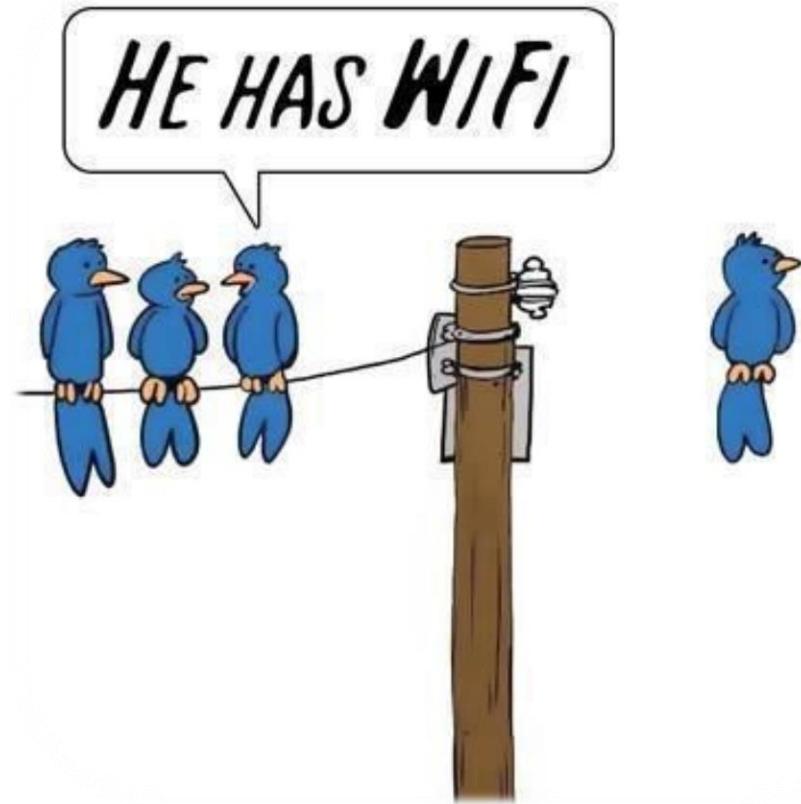
- Allows a computer to get an IP address from a special server
- Uses client-server architecture

# Remote Desktop Protocol (RDP)



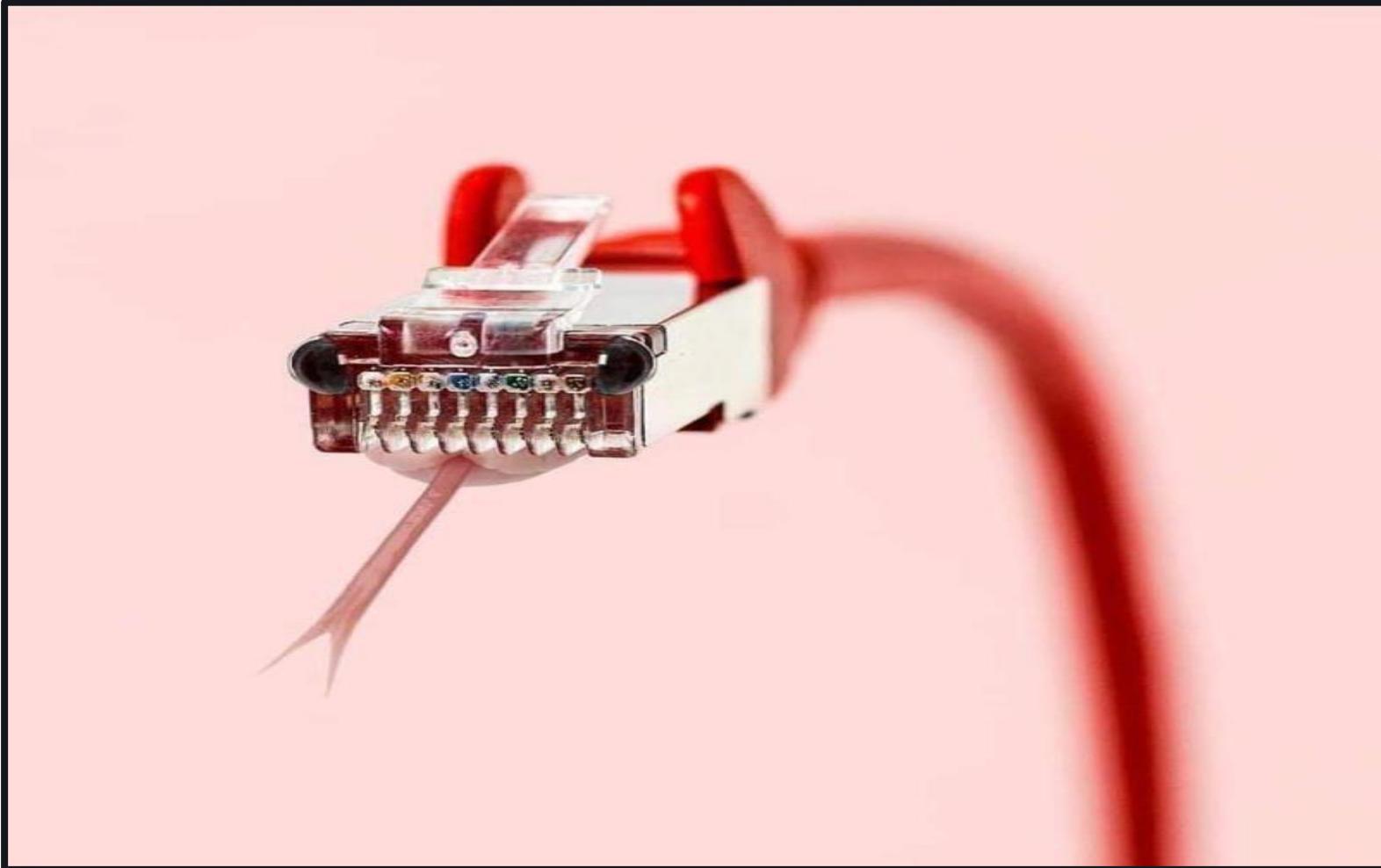
- Provides a graphical interface to connect to another computer over the network
- Can also transfer other resources between the local and remote system, like audio, disk drives and clipboard

# Common Types of Media

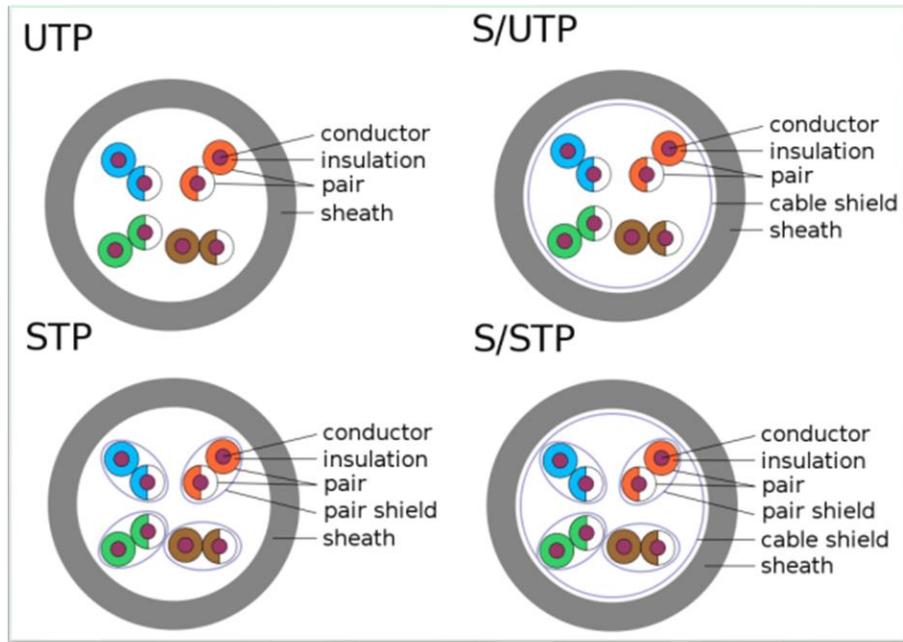


- “X”TP (“something” Twisted Pair). The “twist” idea introduced by Alexander Bell in 1881
- Coaxial Cable
- Fiber Optic
- Wireless

# Let's talk about cables...

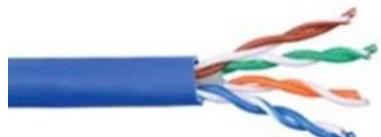


# “X”TP (“something” Twisted Pair)



- Some examples (names can vary):
  - **UTP** – Unshielded Twisted Pair
  - **S/UTP** – Screened UTP
  - **STP** – Shielded Twisted Pair
  - **S/STP** - Screened STP

**U/UTP**  
(Unshielded Cable, Unshielded Pairs)



**F/UTP**  
(Foiled Cable, Unshielded Pairs)



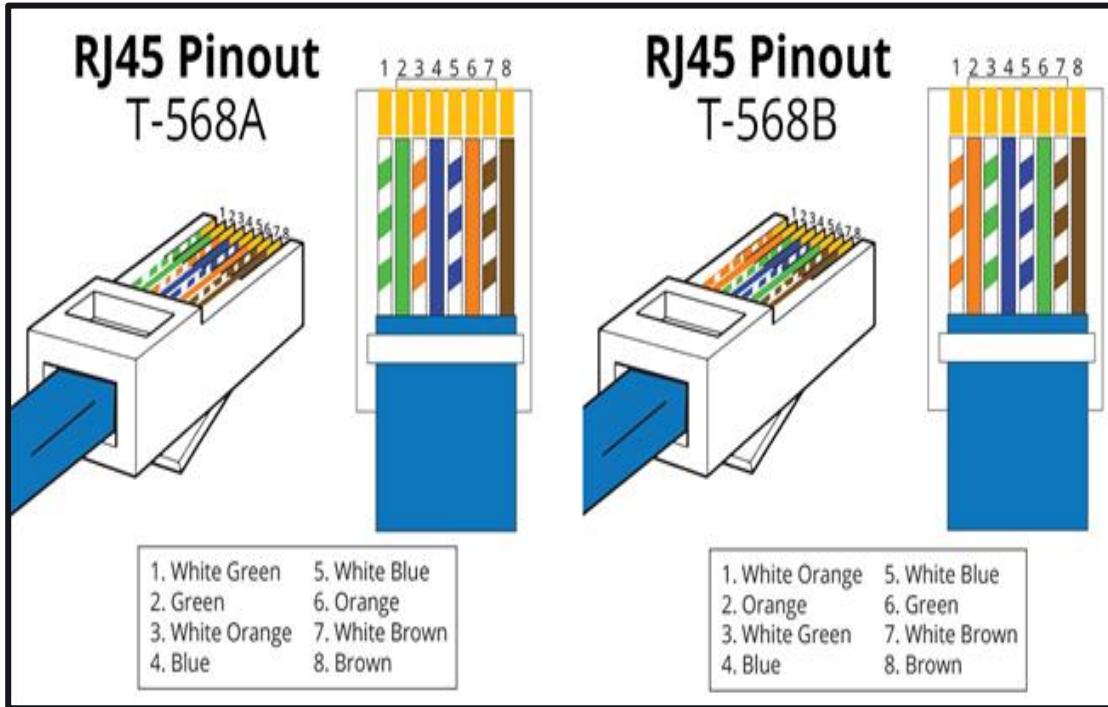
**S/UTP**  
(Shielded Cable, Unshielded Pairs)



**F/FTP**  
(Foiled Cable, Foiled Pairs)



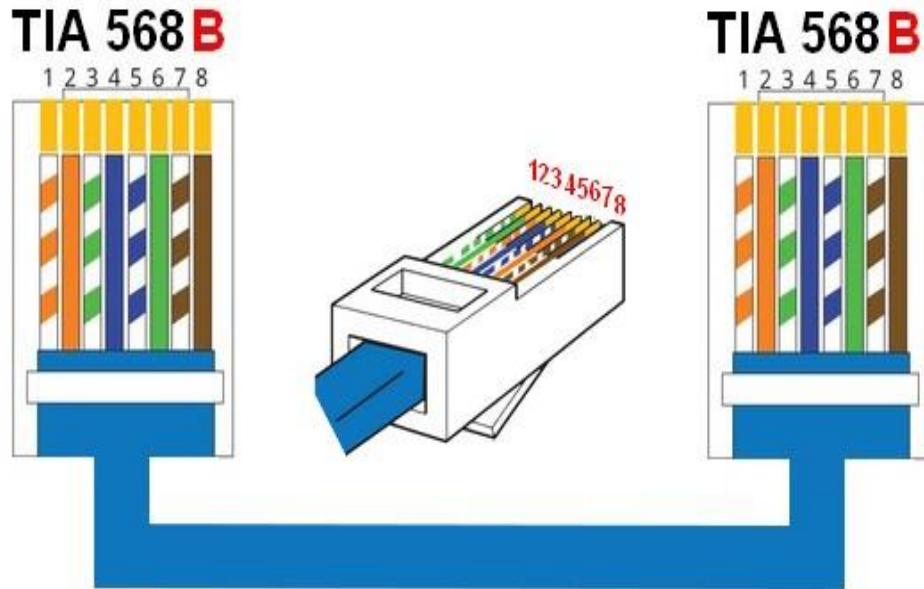
# EIA/TIA Standards



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

# Straight-through Cable

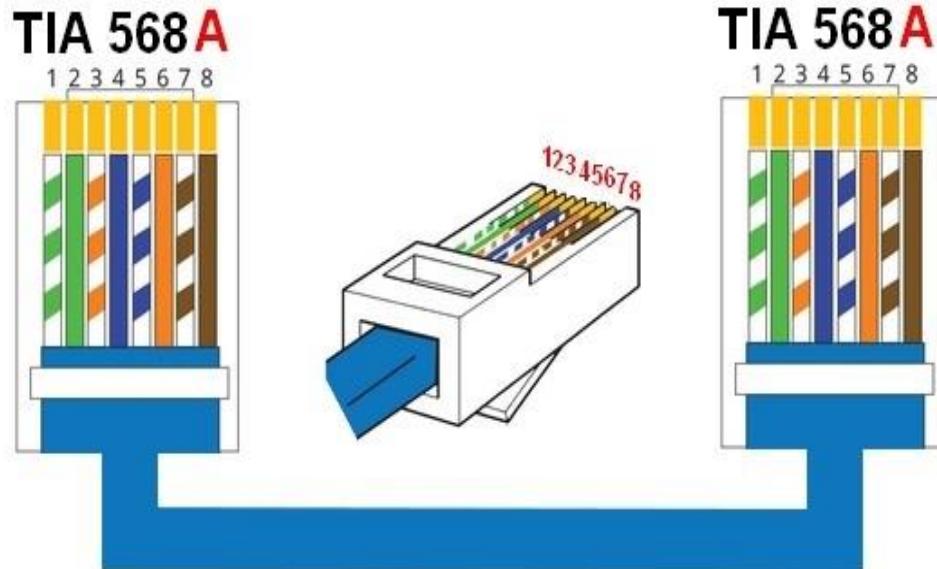
## Straight Through Wiring EIA/TIA 568B



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

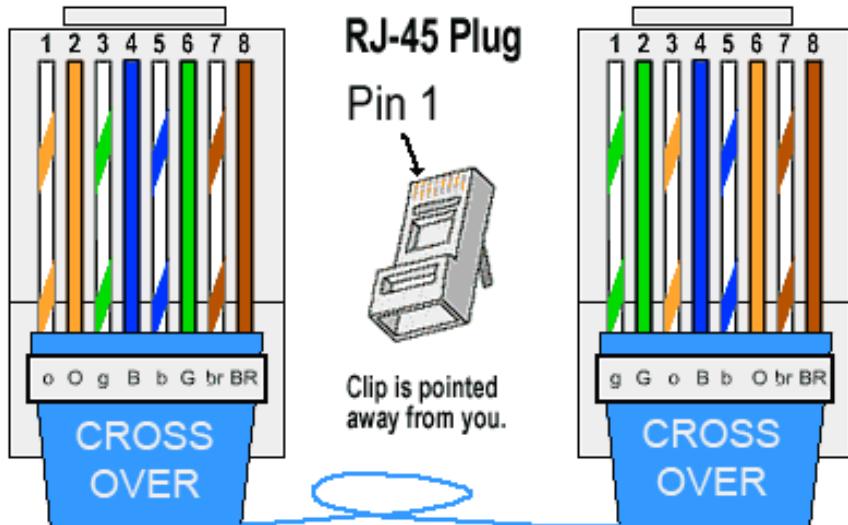
# Straight-through Cable (2)

## Straight Through Wiring EIA/TIA 568A

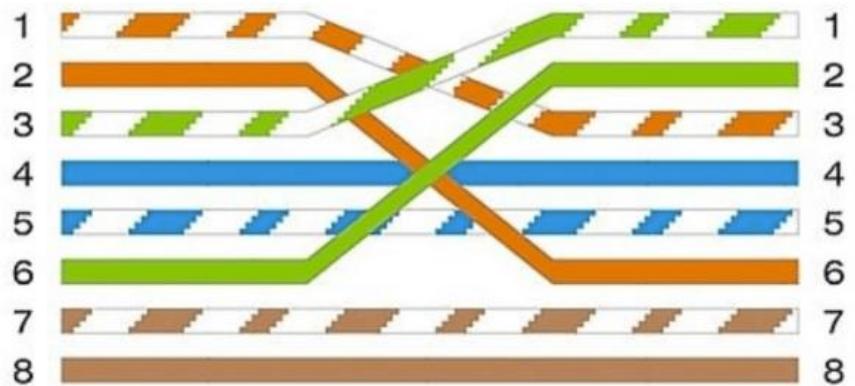


- A “straight” cable can be either:
  - T568B to T568B  
OR
  - T568A to T568A

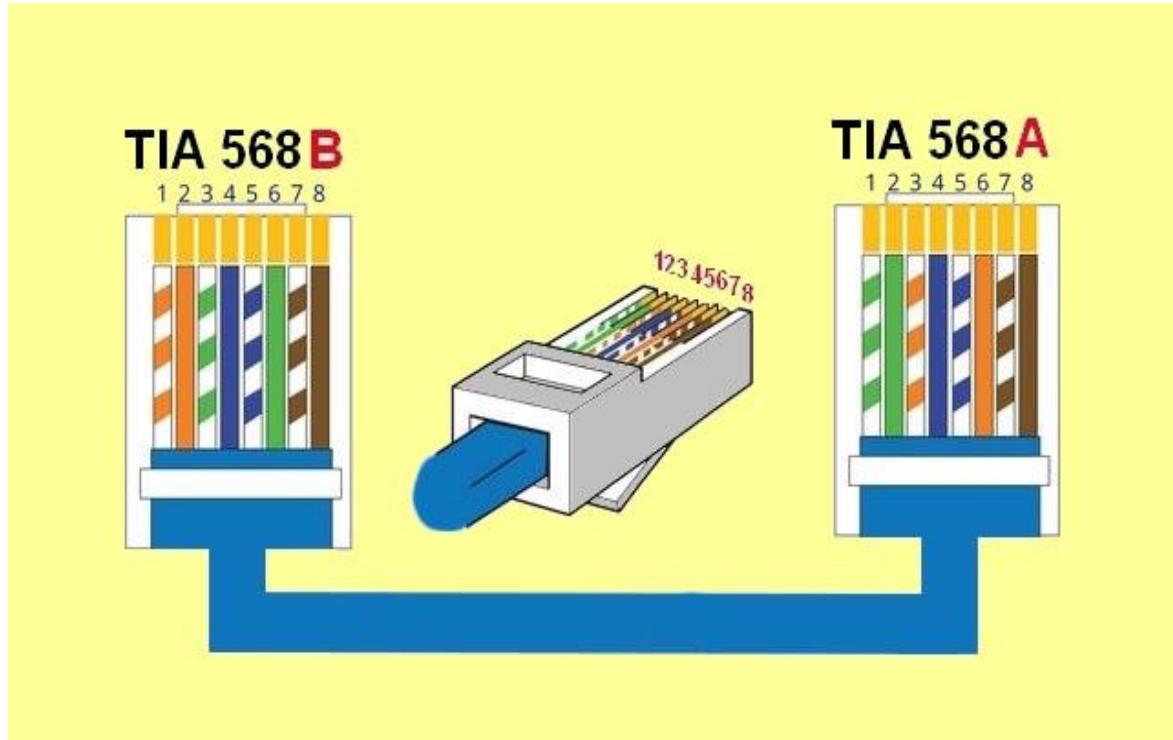
# Crossover Cable



- Pins 1 and 2 from one side go to pins 3 and 6 to the other side, respectively
- 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

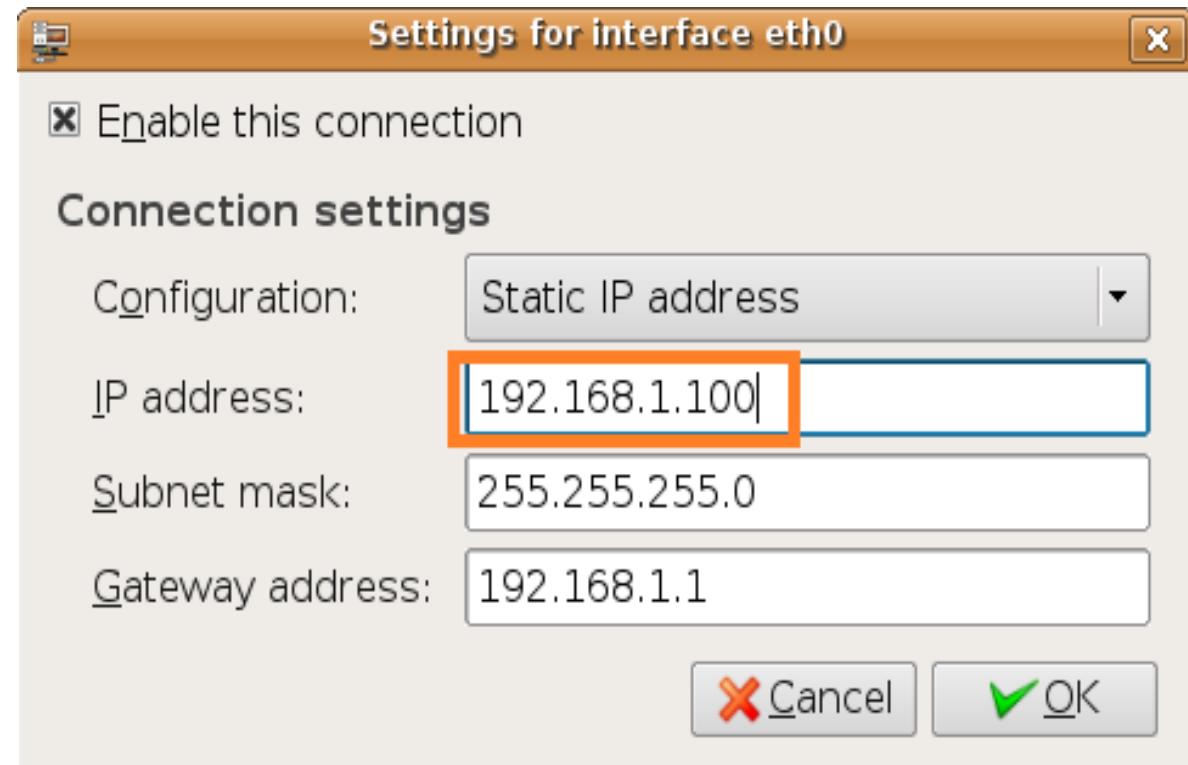
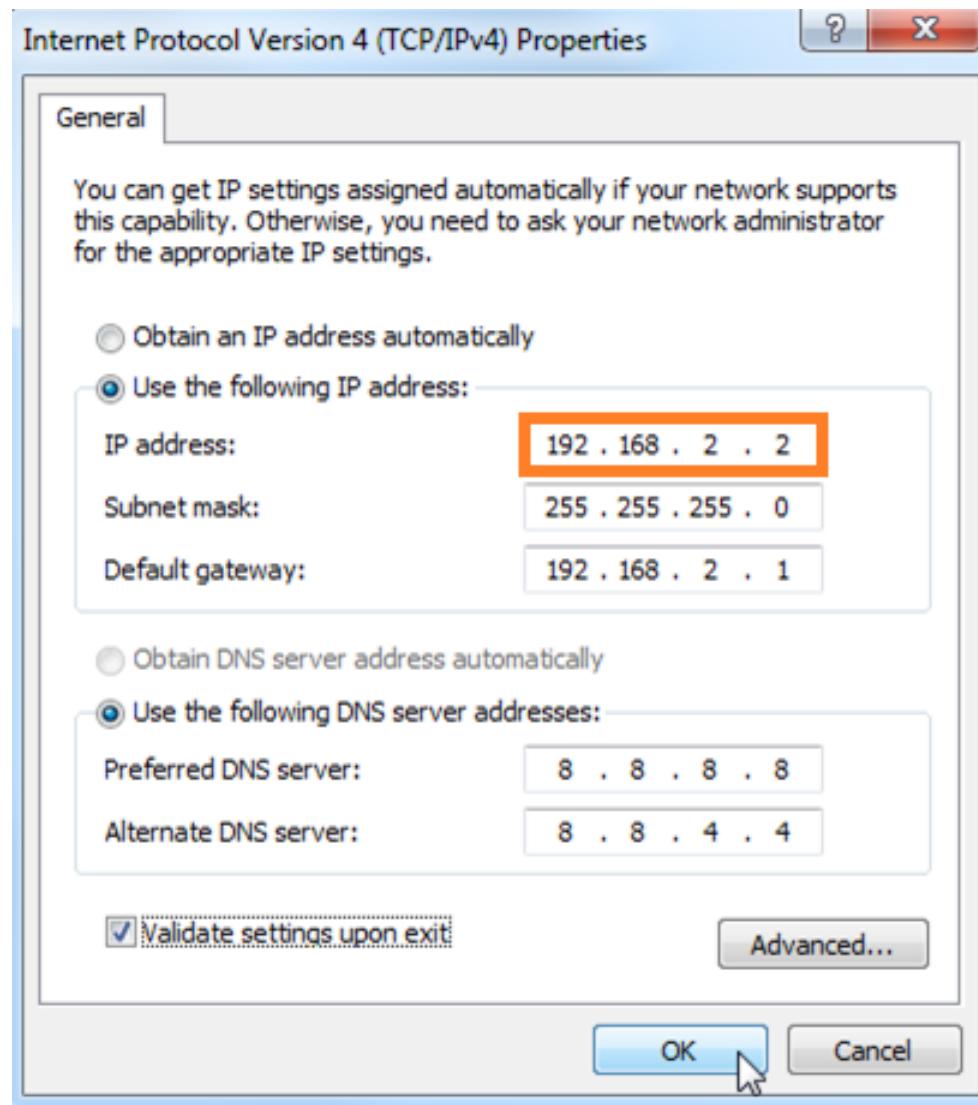


- Used to connect to the **console** of a networking device (switch, router)
- Usually a USB to Serial adapter is also required

# IP and MAC addresses

- 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

## Example MAC Address

**3A-34-52-C4-69-B8**

Organizationally  
Unique Identifier  
(OUI)

Network Interface  
Controller  
(NIC)

- 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

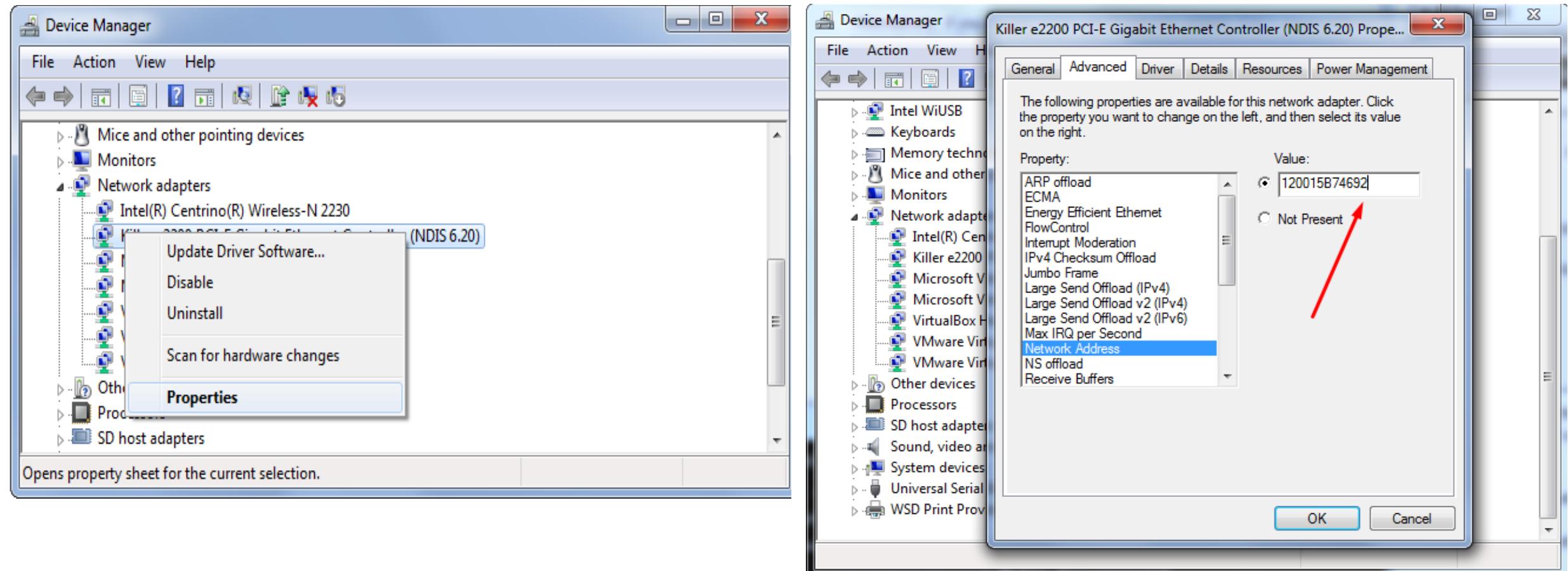
## Windows

```
Command Prompt  
Microsoft Windows [Version 6.1.7601]  
Copyright (c) 2009 Microsoft Corporation. All rights reserved.  
C:\Users\Chris>ipconfig /all  
Wireless LAN adapter Wireless Network Connection:  
  
Connection-specific DNS Suffix . : telus  
Description . . . . . : Intel(R) Centrino(R) Wireless-N 2230  
Physical Address . . . . . : 68-5D-43-66-0B-0C  
DHCP Enabled. . . . . : Yes  
Autoconfiguration Enabled . . . . . : Yes  
Link-local IPv6 Address . . . . . : fe80::799d:c5a7:c72:b925%11<Preferred>  
IPv4 Address. . . . . : 192.168.1.66<Preferred>  
Subnet Mask . . . . . : 255.255.255.0  
Lease Obtained. . . . . : June-24-14 6:52:06 PM  
Lease Expires . . . . . : June-25-14 6:52:05 PM  
Default Gateway . . . . . : 192.168.1.254  
DHCP Server . . . . . : 192.168.1.254  
DHCPv6 IAID . . . . . : 234886400  
DHCPv6 Client DUID. . . . . : 00-01-00-01-17-67-D7-29-8C-89-A5-02-93-A  
DNS Servers . . . . . : 8.8.8.8  
                      : 8.8.4.4  
NetBIOS over Tcpip. . . . . : Enabled  
  
Ethernet adapter Local Area Connection:  
  
Media State . . . . . : Media disconnected  
Connection-specific DNS Suffix . . . . . :  
Description . . . . . . . . . : Killer e2200 PCI-E Gigabit Ethernet Controller (NDIS 6.20)  
Physical Address. . . . . . . . . : 8C-89-A5-02-93-AF  
DHCP Enabled. . . . . . . . . : Yes  
Autoconfiguration Enabled . . . . . . . . . : Yes
```

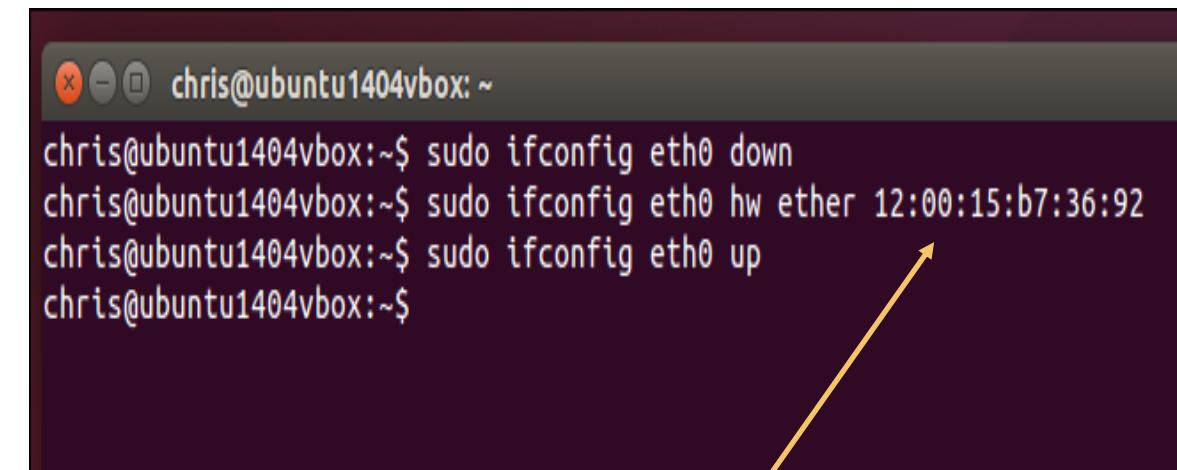
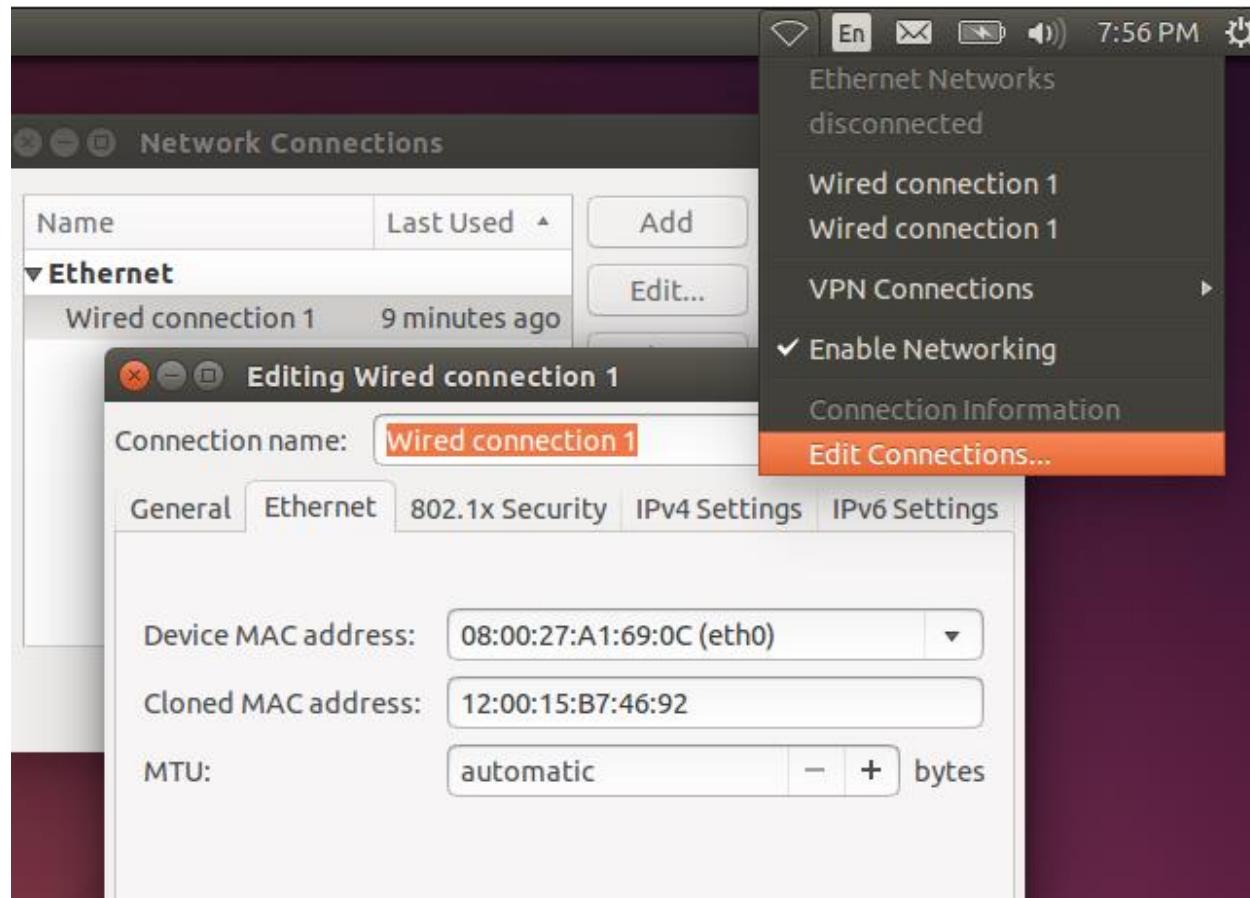
## Linux

```
ubuntu@ubuntu:~$ ifconfig -a  
eth0      Link encap:Ethernet HWaddr 08:00:27:62:bf:e1  
          inet addr:10.0.2.15 Bcast:10.0.2.255 Mask:255.255.255.0  
          inet6 addr: fe80::a00:27ff:fe62:bfe1/64 Scope:Link  
          UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1  
          RX packets:60 errors:0 dropped:0 overruns:0 frame:0  
          TX packets:121 errors:0 dropped:0 overruns:0 carrier:0  
          collisions:0 txqueuelen:1000  
          RX bytes:19935 (19.9 KB) TX bytes:14448 (14.4 KB)  
  
lo       Link encap:Local Loopback  
          inet addr:127.0.0.1 Mask:255.0.0.0  
          inet6 addr: ::1/128 Scope:Host  
          UP LOOPBACK RUNNING MTU:16436 Metric:1  
          RX packets:44 errors:0 dropped:0 overruns:0 frame:0  
          TX packets:44 errors:0 dropped:0 overruns:0 carrier:0  
          collisions:0 txqueuelen:0  
          RX bytes:4013 (4.0 KB) TX bytes:4013 (4.0 KB)
```

# How to Modify a MAC Address in Windows



# How to Modify a MAC Address in Linux



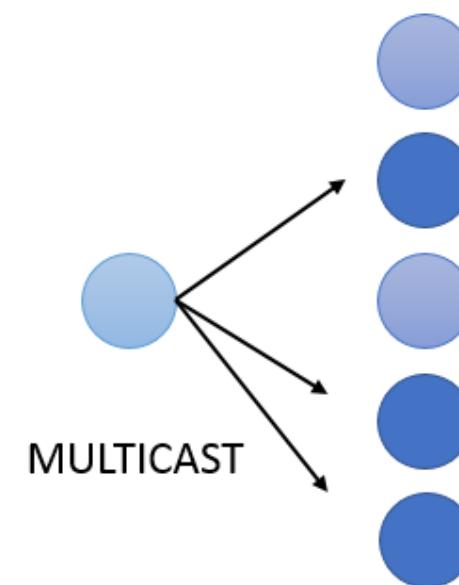
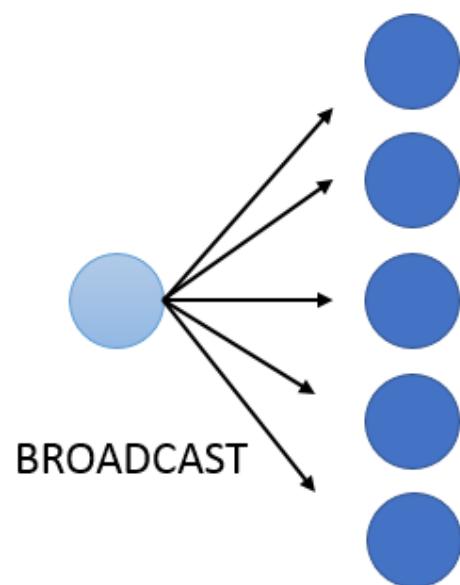
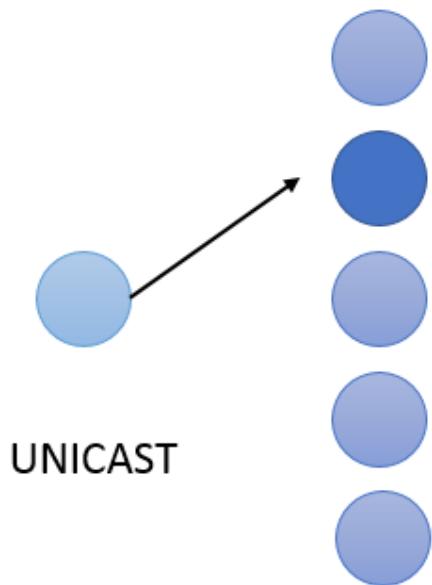
```
chris@ubuntu1404vbox:~$ sudo ifconfig eth0 down
chris@ubuntu1404vbox:~$ sudo ifconfig eth0 hw ether 12:00:15:b7:36:92
chris@ubuntu1404vbox:~$ sudo ifconfig eth0 up
chris@ubuntu1404vbox:~$
```

The new MAC address

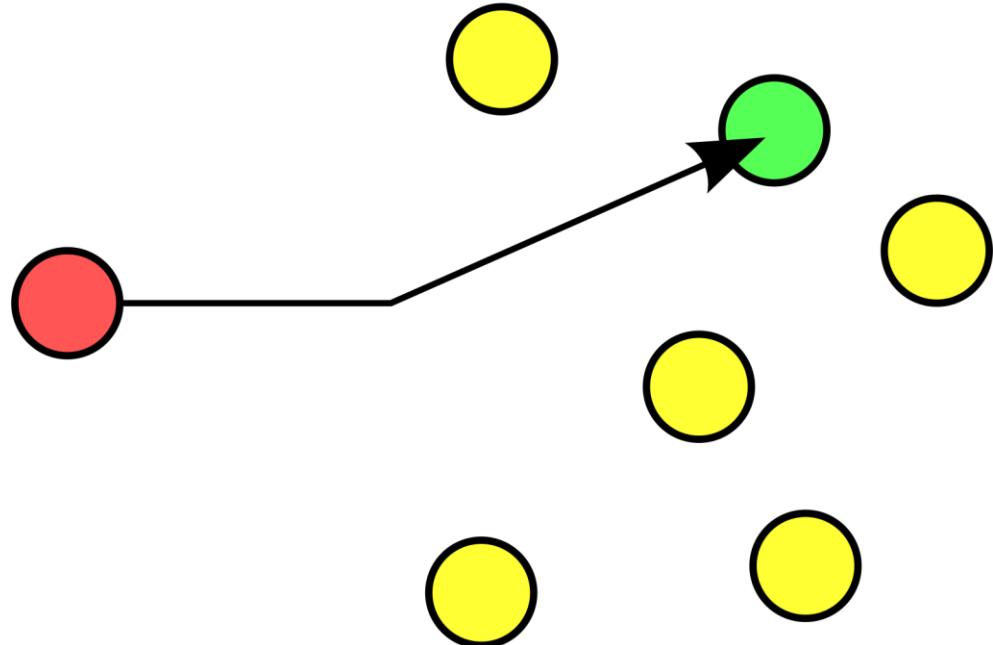
# Traffic Types

# Types of traffic

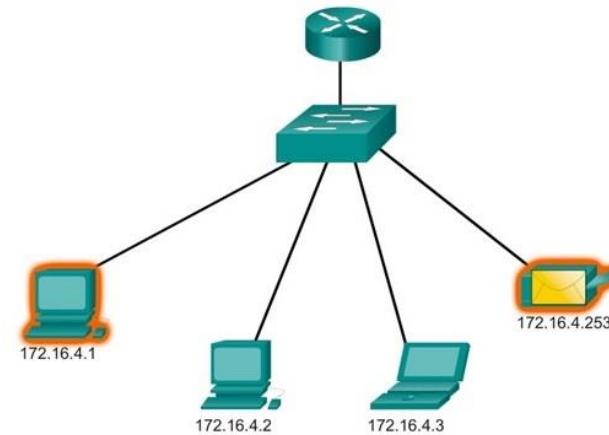
- ONE TO ONE (UNICAST)
- ONE TO ALL (BROADCAST)
- ONE TO SEVERAL (MULTICAST)



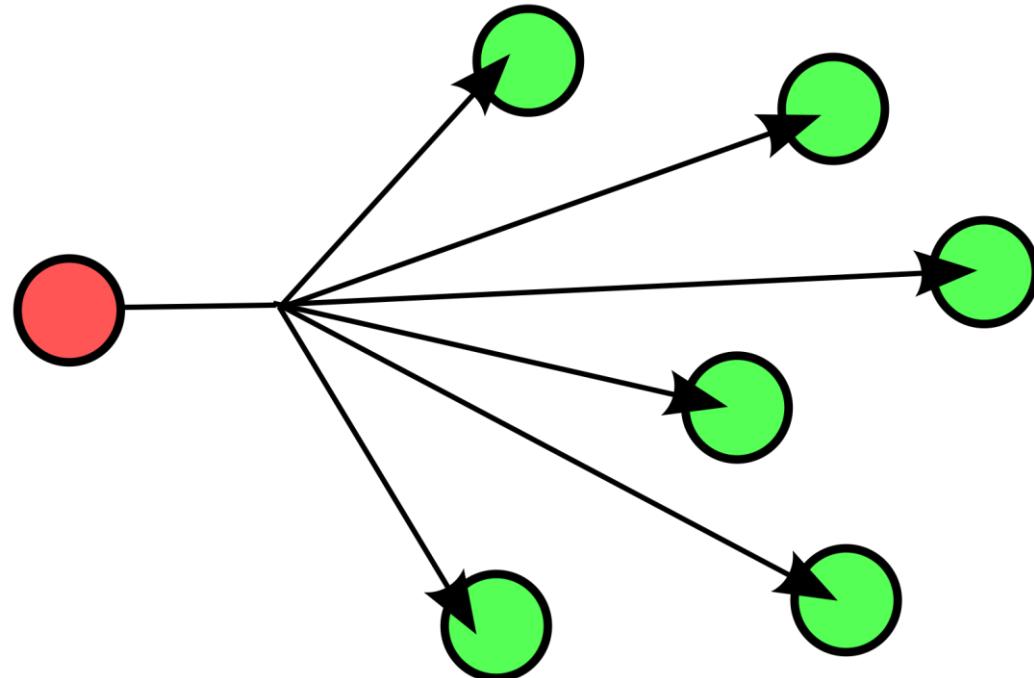
# Unicast



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



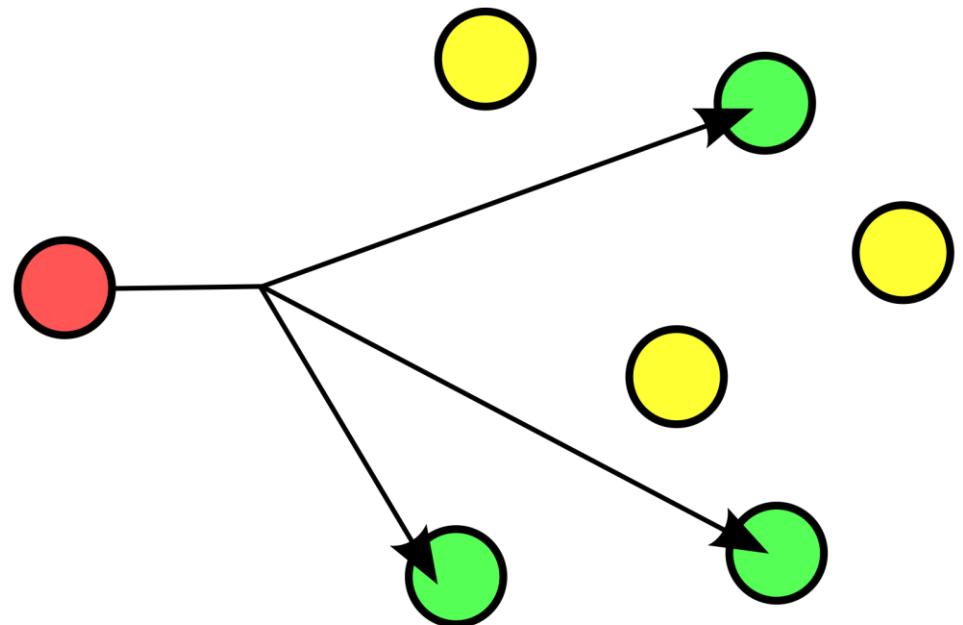
# Broadcast



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

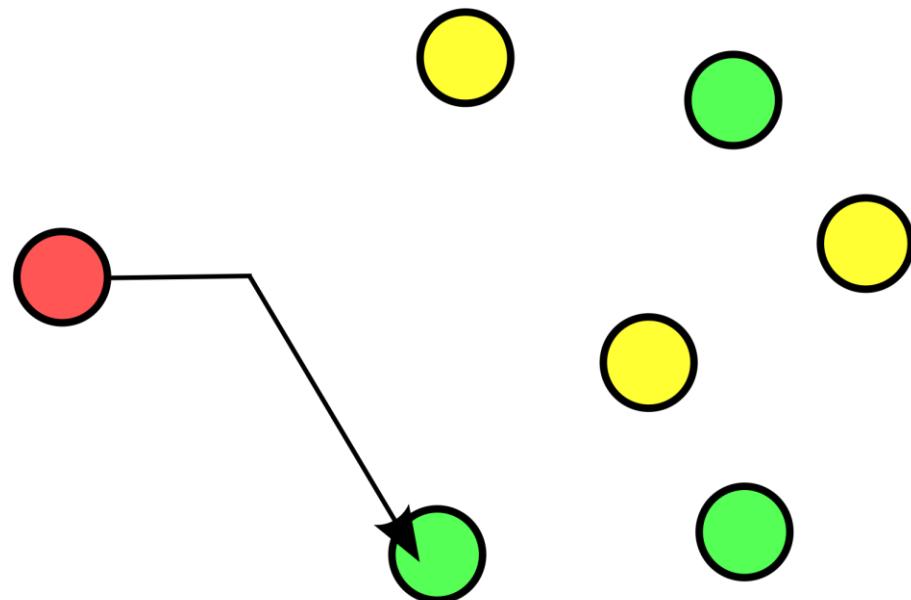


# Multicast



- 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

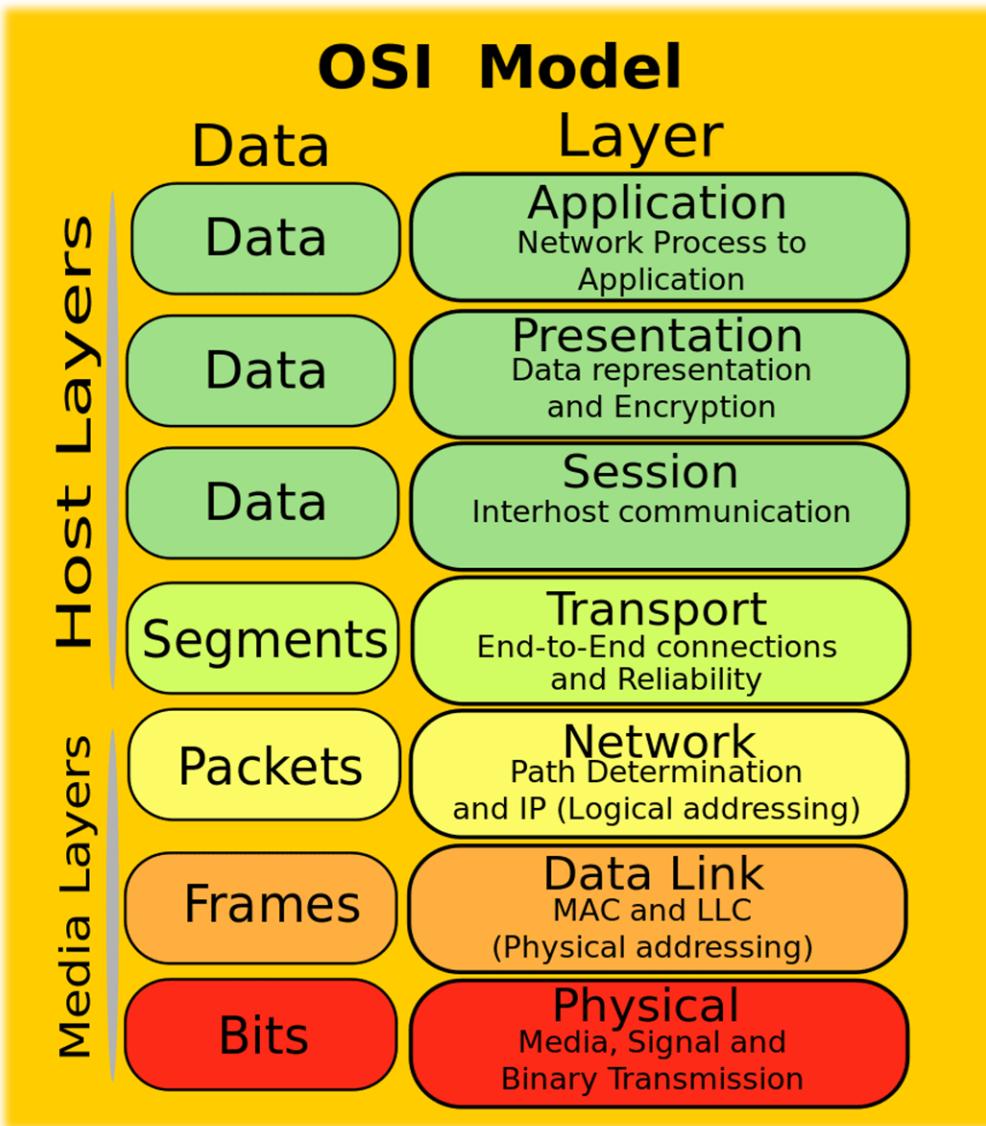
# Anycast



- 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

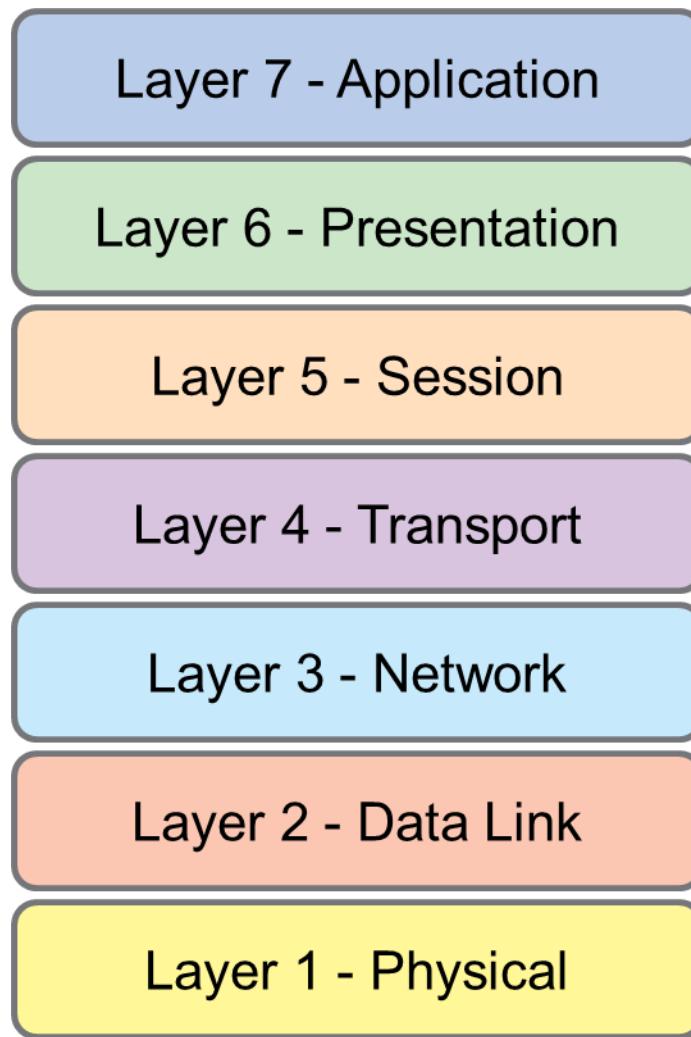
# OSI and TCP/IP models

# OSI Model



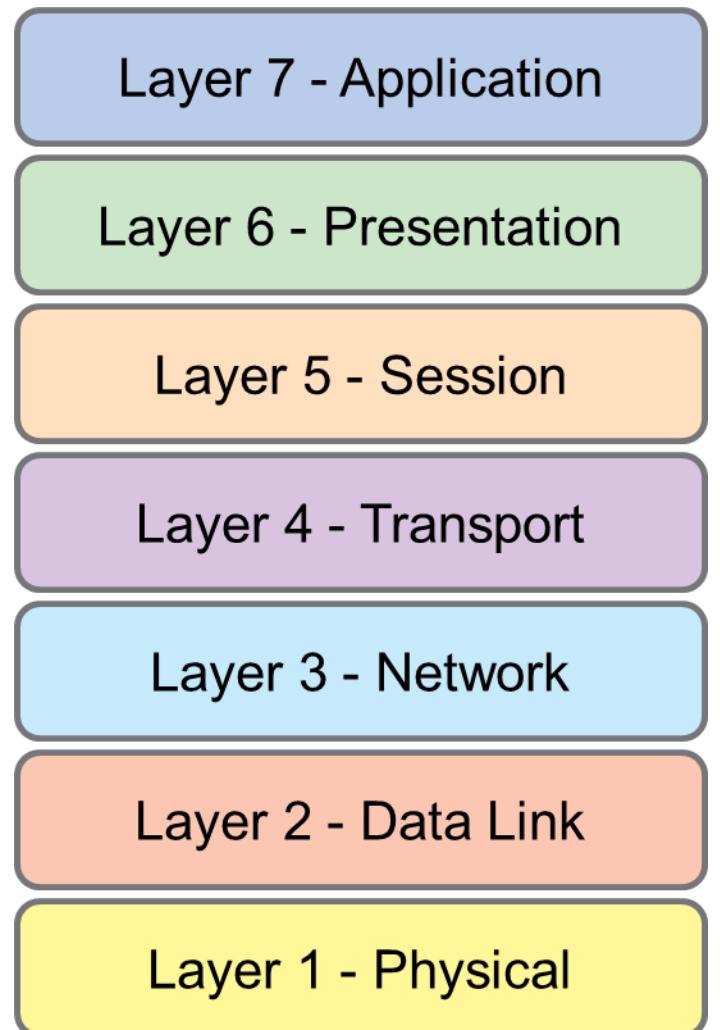
- OSI = Open Systems Interconnection
- Why?
  - Organizes the information
  - Simplifies learning
  - Standards for the vendors
  - Easier troubleshooting
- Protocol Data Unit (PDU) – different data format at each layer

# Layer 1 - Physical



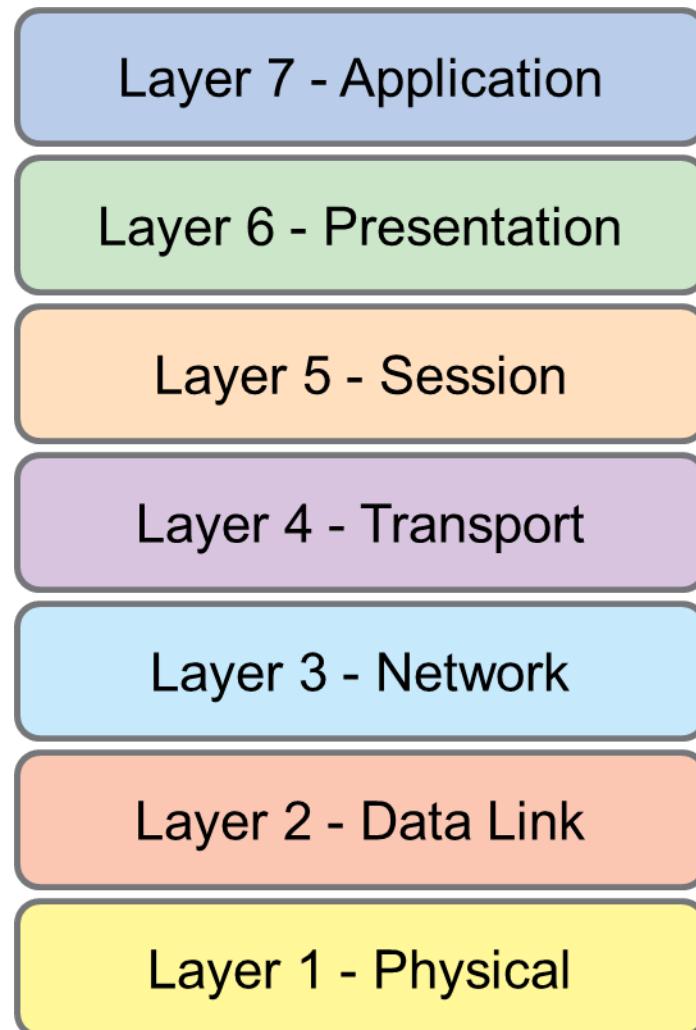
- The first and lowest layer
- Transmitting raw bits
- Wiring standards
- Devices: hubs, repeaters, modems, cabling, connectors
- Protocols: USB, Infrared, Bluetooth

# Layer 2 – Data Link



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

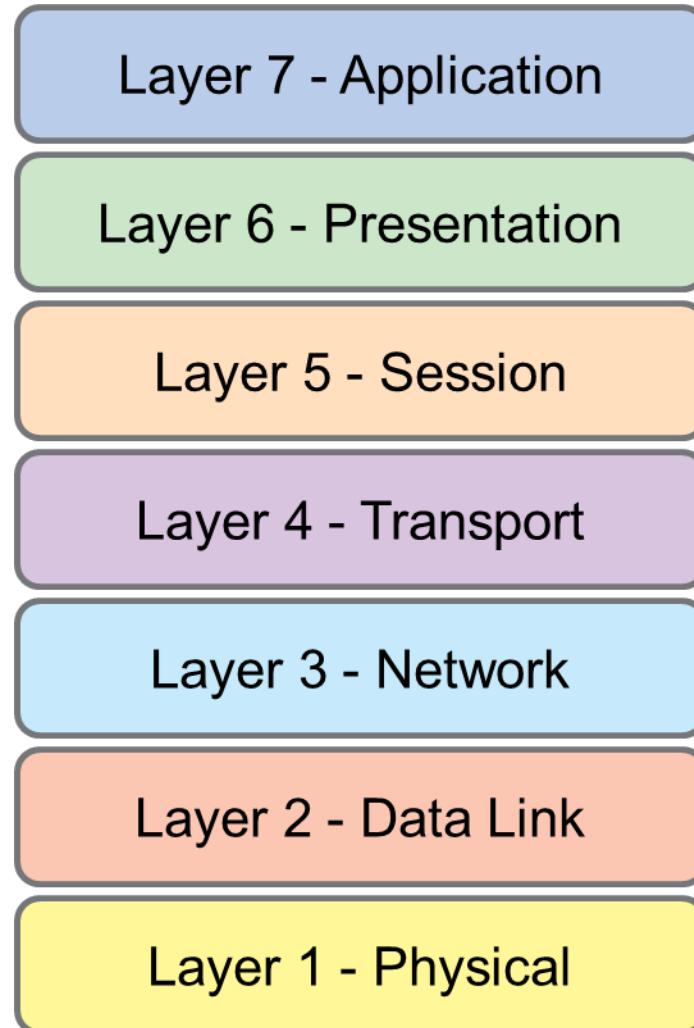
# Layer 3 – Network



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

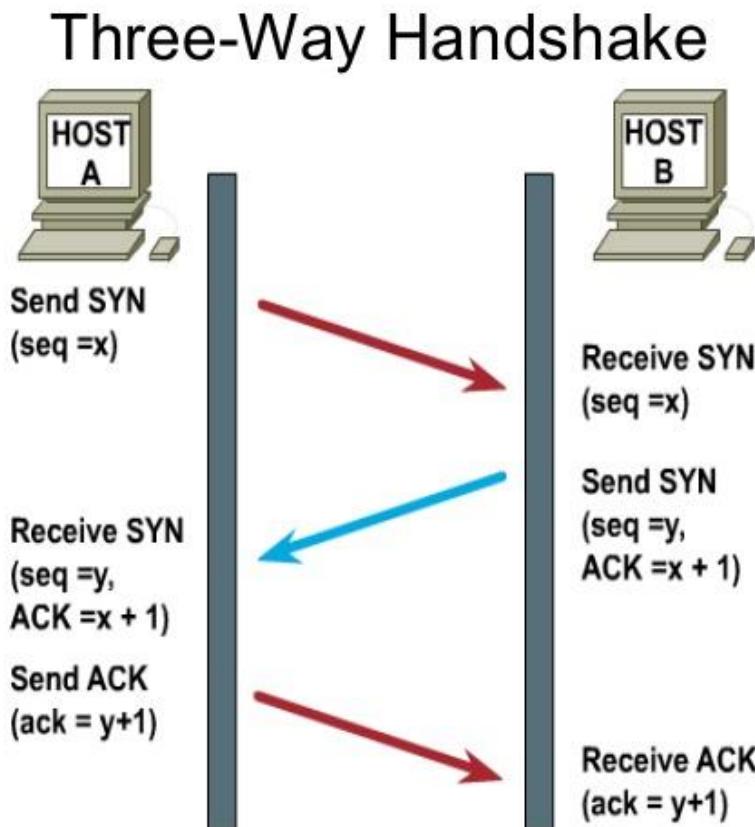


# Layer 4 – Transport



- 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



**Kirk Bater**

@KirkBater

Follow

▼

This image is a TCP/IP Joke. This tweet is a UDP joke. I don't care if you get it.

## Thread

iamkirkbater and jkjustjoshing

 **iamkirkbater** Aug 23rd, 2017 at 9:37 AM  
in #www

Do you want to hear a joke about TCP/IP?

 7

7 replies

 **jkjustjoshing** 5 months ago

Yes, I'd like to hear a joke about TCP/IP

 **iamkirkbater** 5 months ago

Are you ready to hear the joke about TCP/IP?

 **jkjustjoshing** 5 months ago

I am ready to hear the joke about TCP/IP

 **iamkirkbater** 5 months ago

Here is a joke about TCP/IP.

 **iamkirkbater** 5 months ago

Did you receive the joke about TCP/IP?

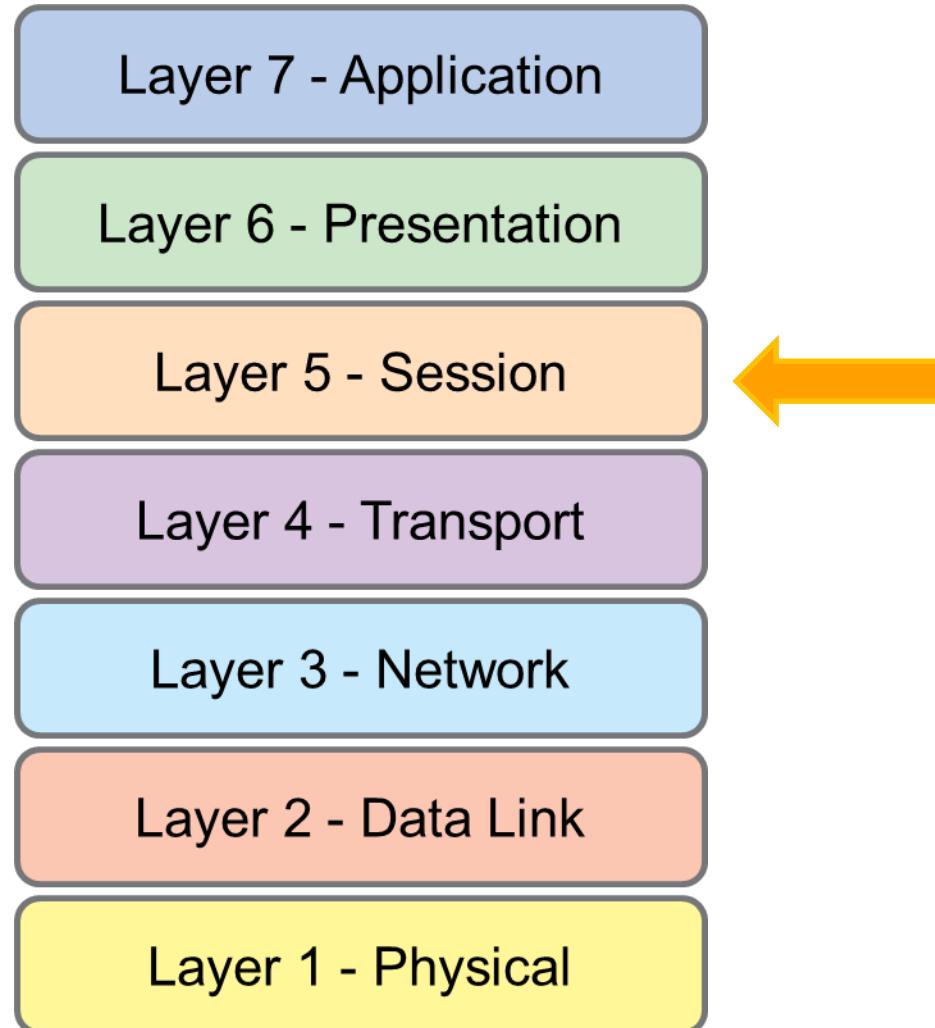
 **jkjustjoshing** 5 months ago

I have received the joke about TCP/IP.

 **iamkirkbater** 5 months ago

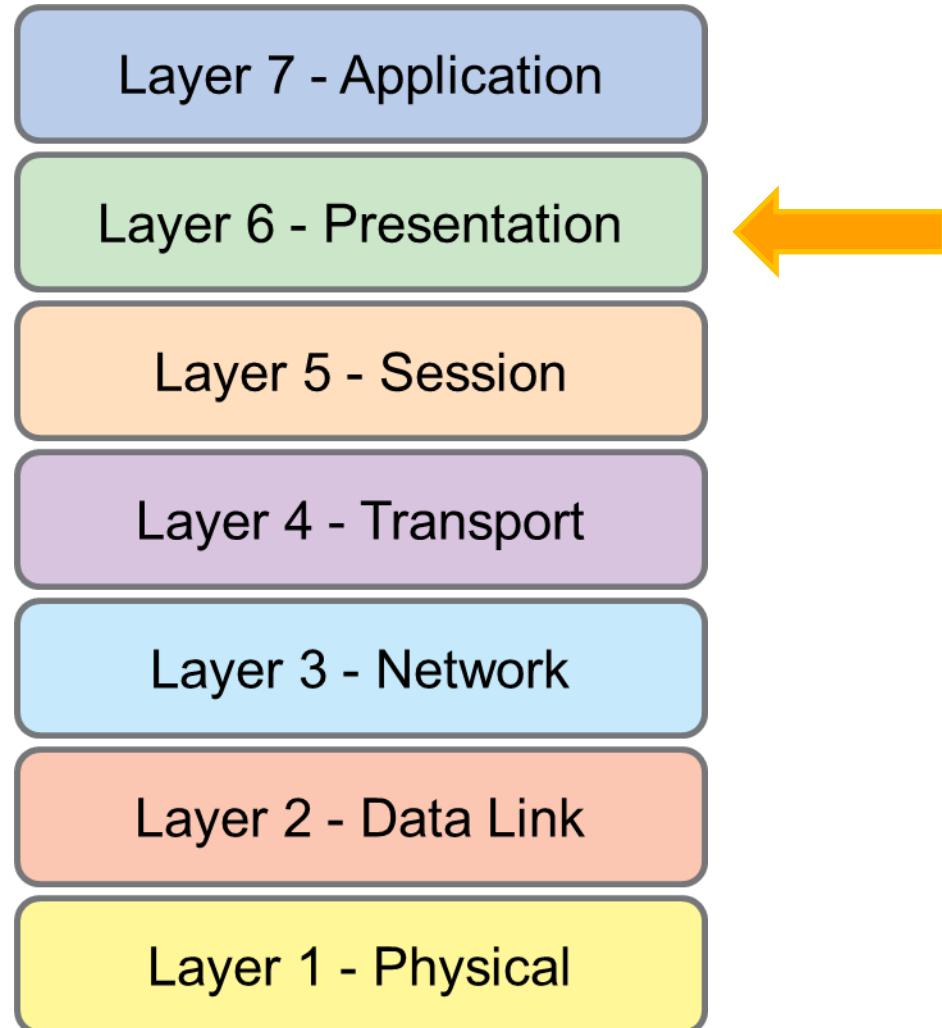
Excellent. You have received the joke about TCP/IP. Goodbye.

# Layer 5 – Session



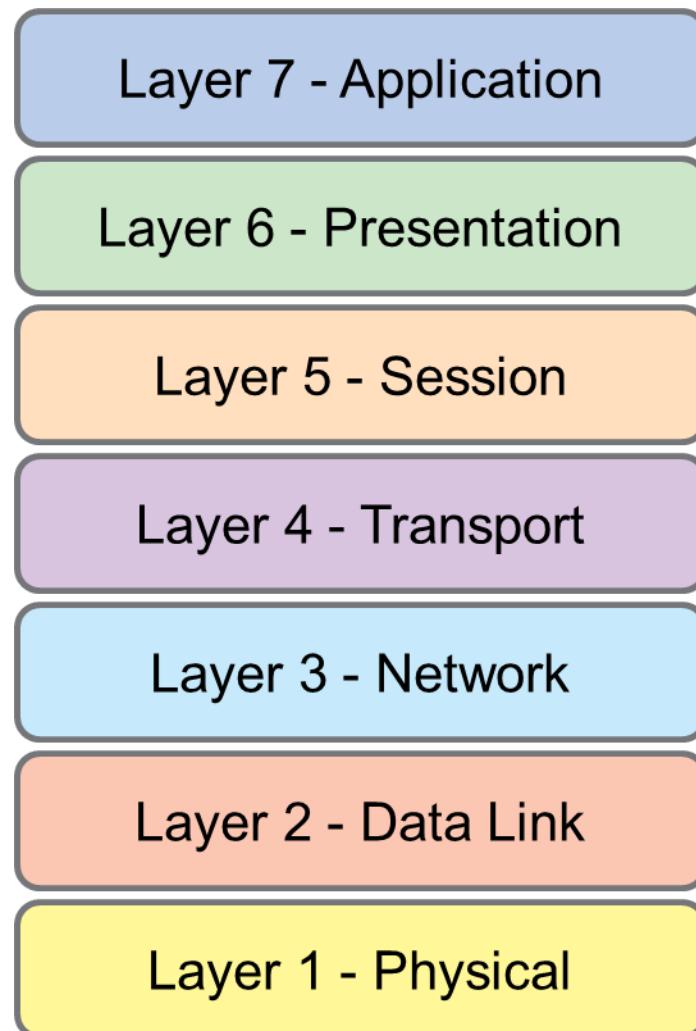
- Opening, closing and managing a session
- Services:
  - Authentication
  - Authorization
  - Session restoration
- Protocols: PPTP, L2TP, NetBIOS, RPC

# Layer 6 – Presentation



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

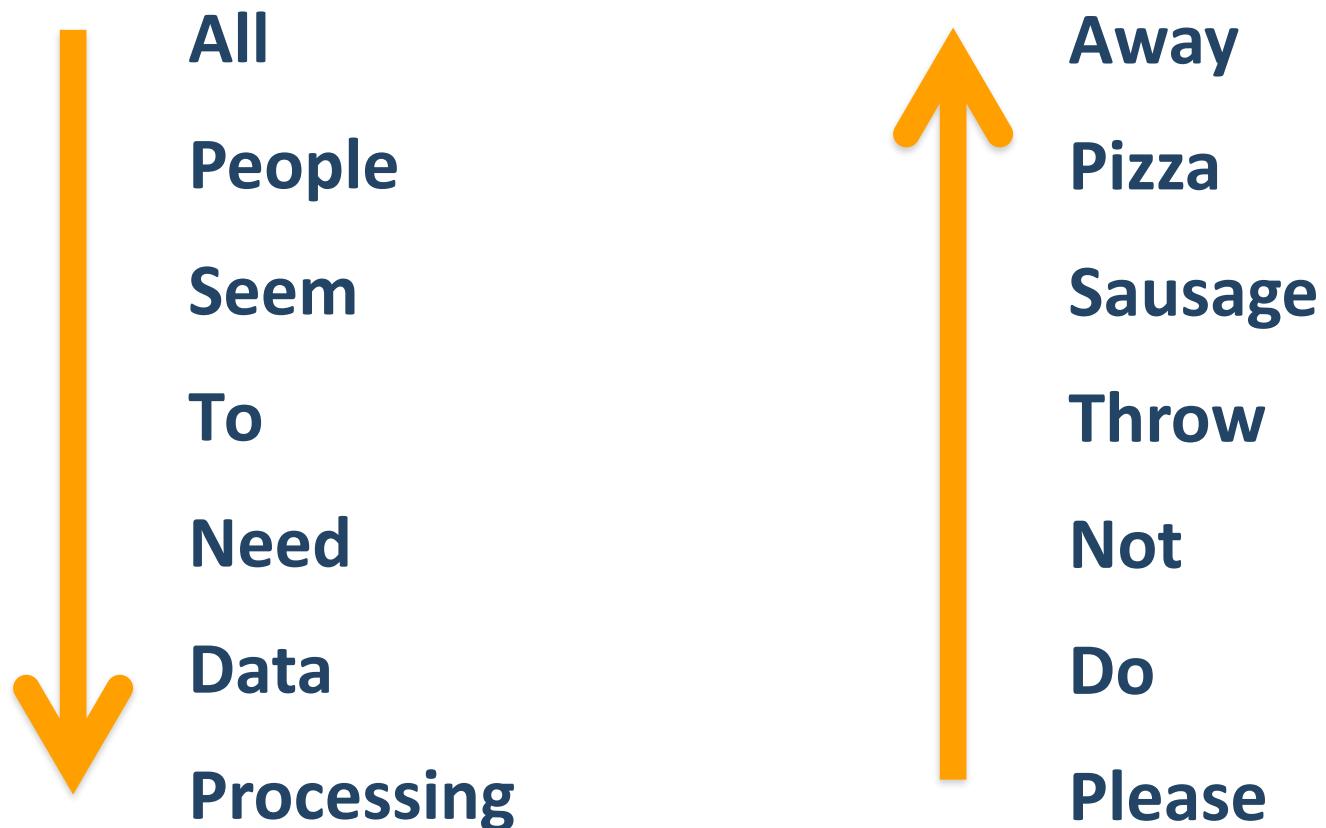
# Layer 7 – Application



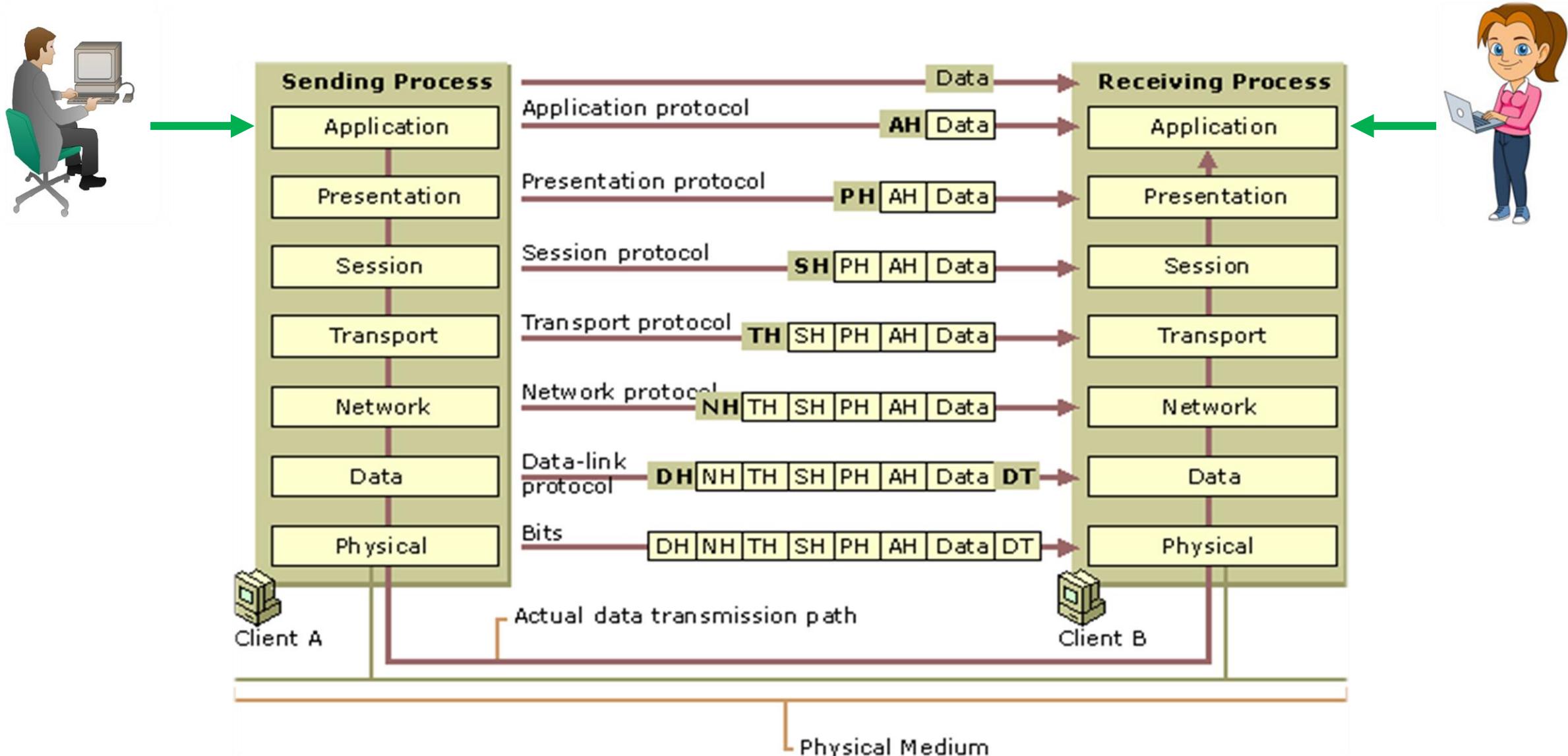
- End-user interaction with the network
- Protocols: HTTP(s), FTP, SMTP, Telnet, SSH, RDP



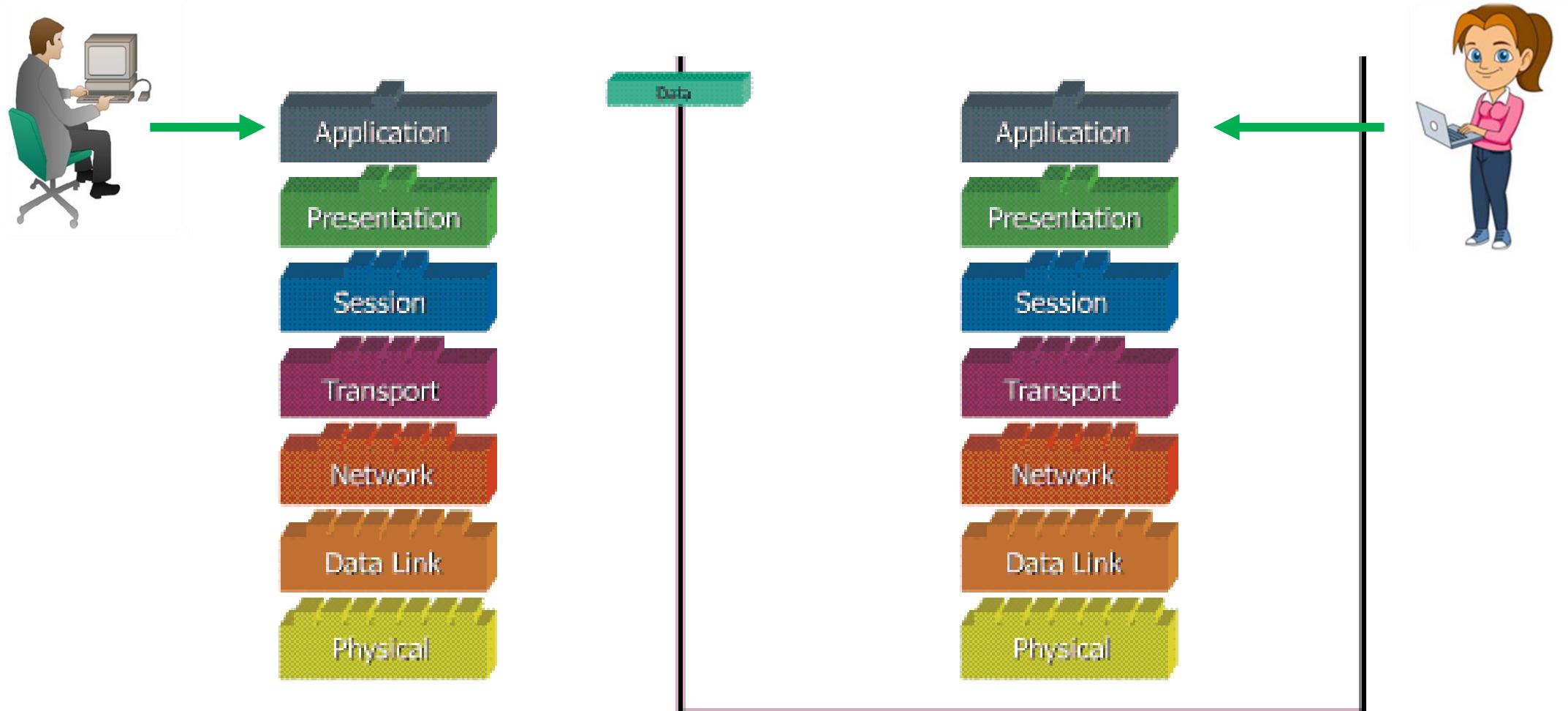
# Mnemonics for the OSI Model



# 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 OSI model criticism

- The OSI model has often been criticized:
  - Sometimes it is more theoretical than practical
  - It is complicated
  - It had bad timing
- Despite of this, it still provides a good value and is very widely accepted
- Other networking models also exist (next slide)

Robert Graham  
@ErrataRob

Yea, I've got 3 hours to kill here in this airport lounge waiting for the next leg of my flight, so let's discuss the "OSI Model". There's no such thing. What they taught you is a lie, and they knew it was a lie, and they didn't care, because they are jerks.

11:43 PM · Aug 27, 2019 · Twitter Web App

858 Retweets 243 Quote Tweets 2,229 Likes

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Robert Graham @ErrataRob · Aug 27, 2019

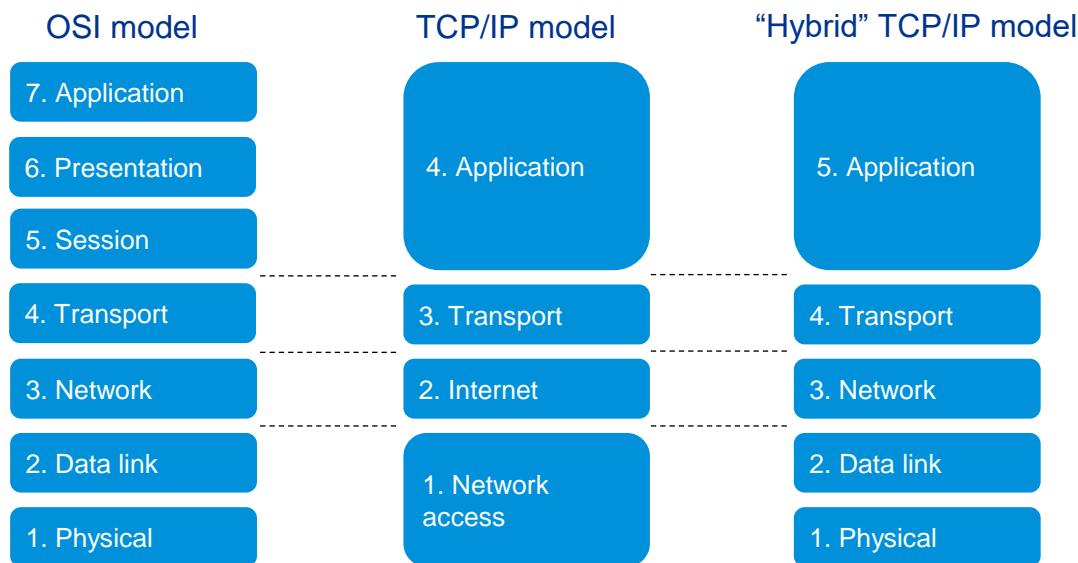
Replies to @ErrataRob

You know what REALLY happened when the kid pointed out the king was wearing no clothes? The kid was punished. Nobody cared. And the king went on wearing the same thing, which everyone agreed was made from the finest of cloth.

4 Retweets 34 Likes 238 Shares

# Other networking models

- Originally, the “TCP/IP model” was developed before the OSI model
- Later, multiple other models were created
- The “hybrid TCP/IP model” is considered as one of the most practical models today



[Wikipedia: Internet protocol suite](#)

# 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



# Questions?



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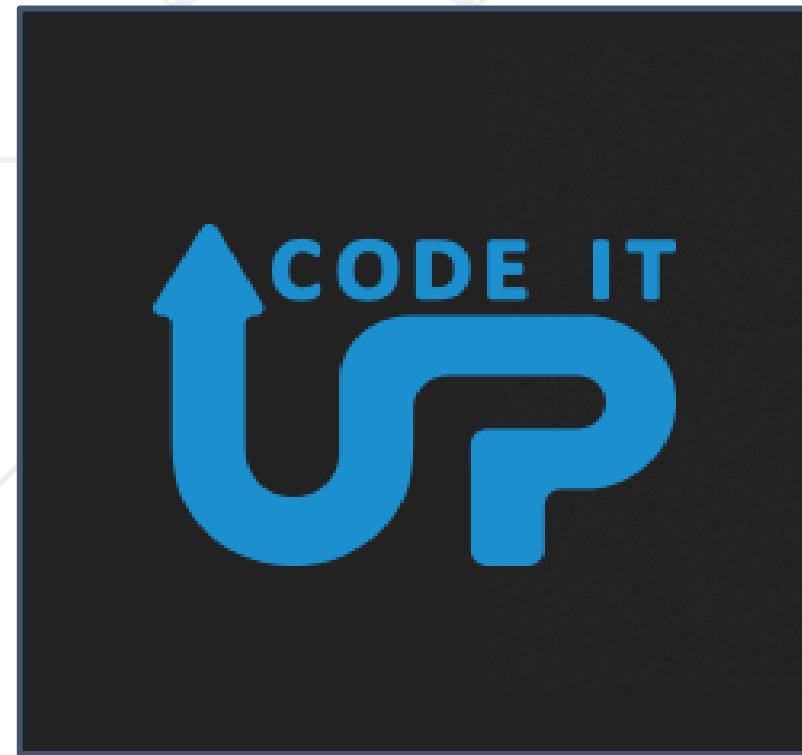
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