

Introduction to Networking

Lecture 1

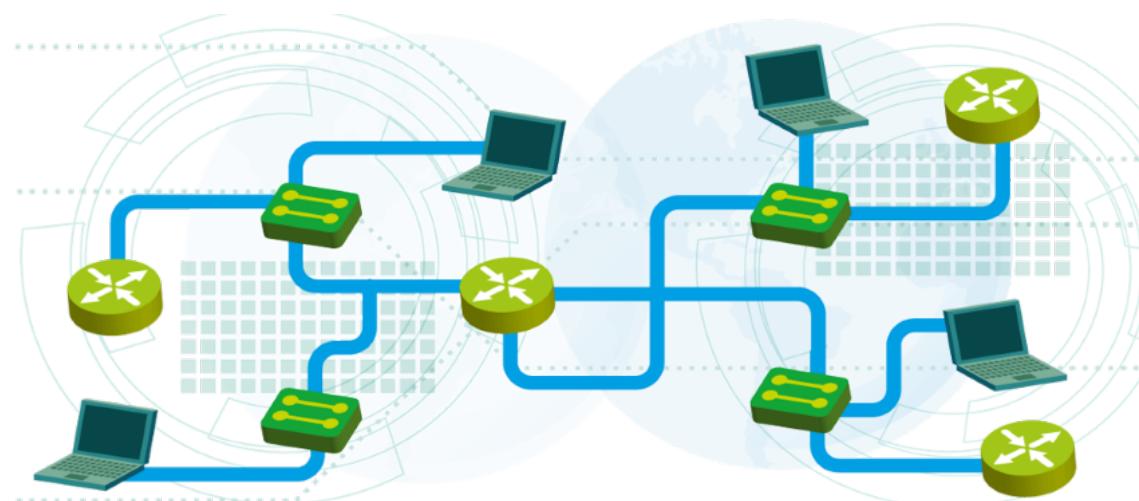
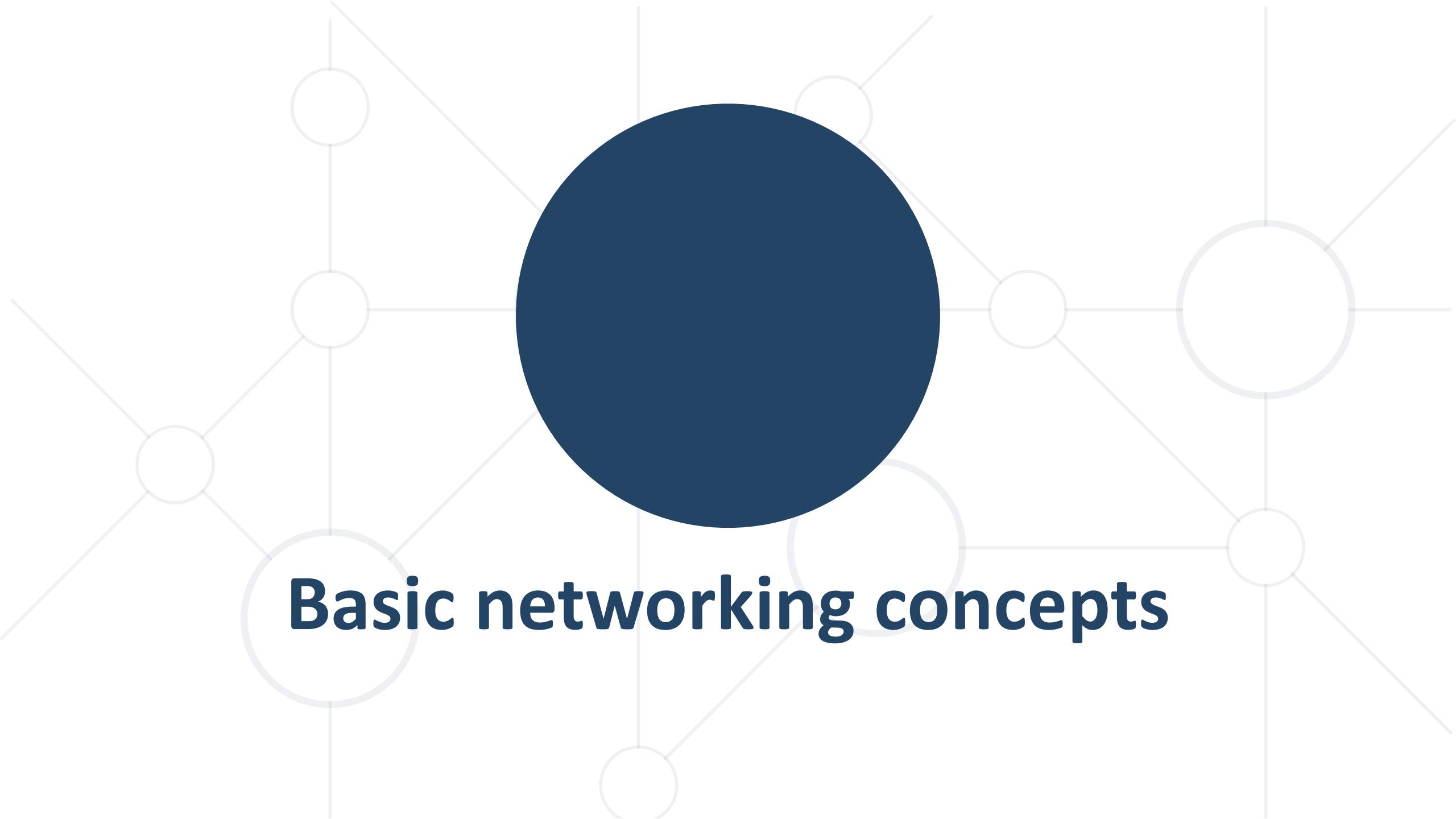


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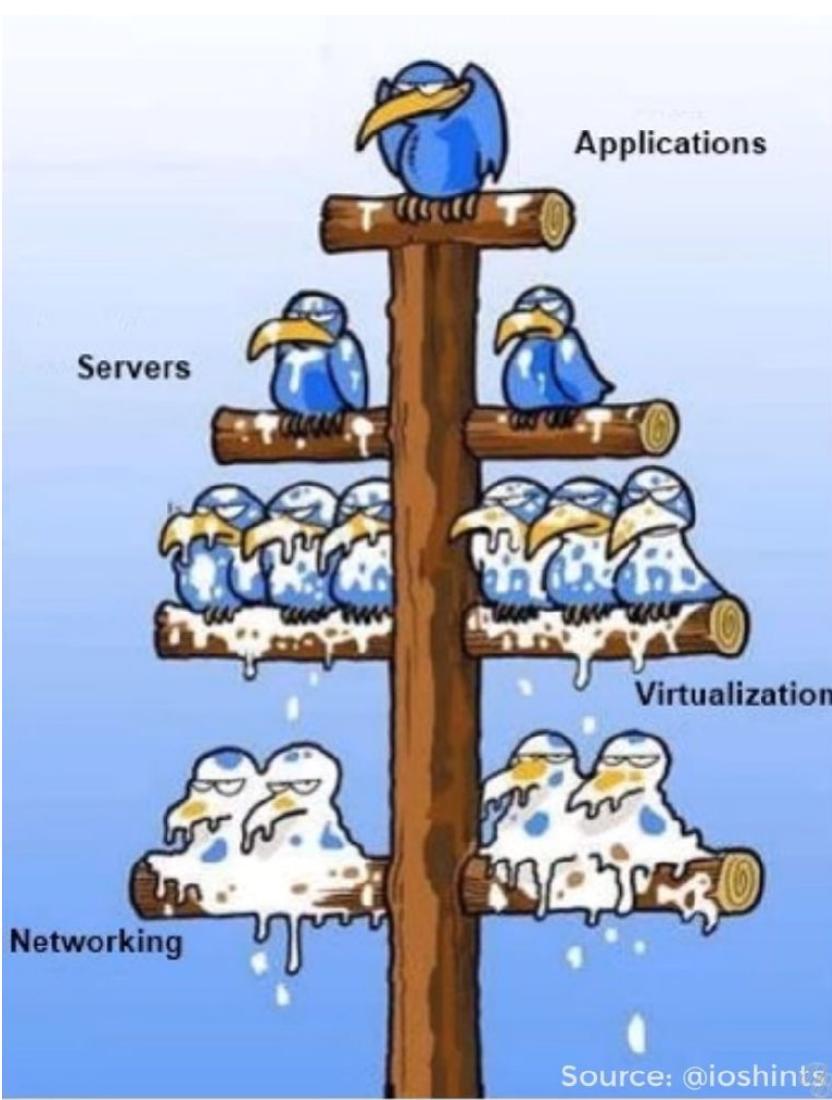
Basic networking concepts

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!”

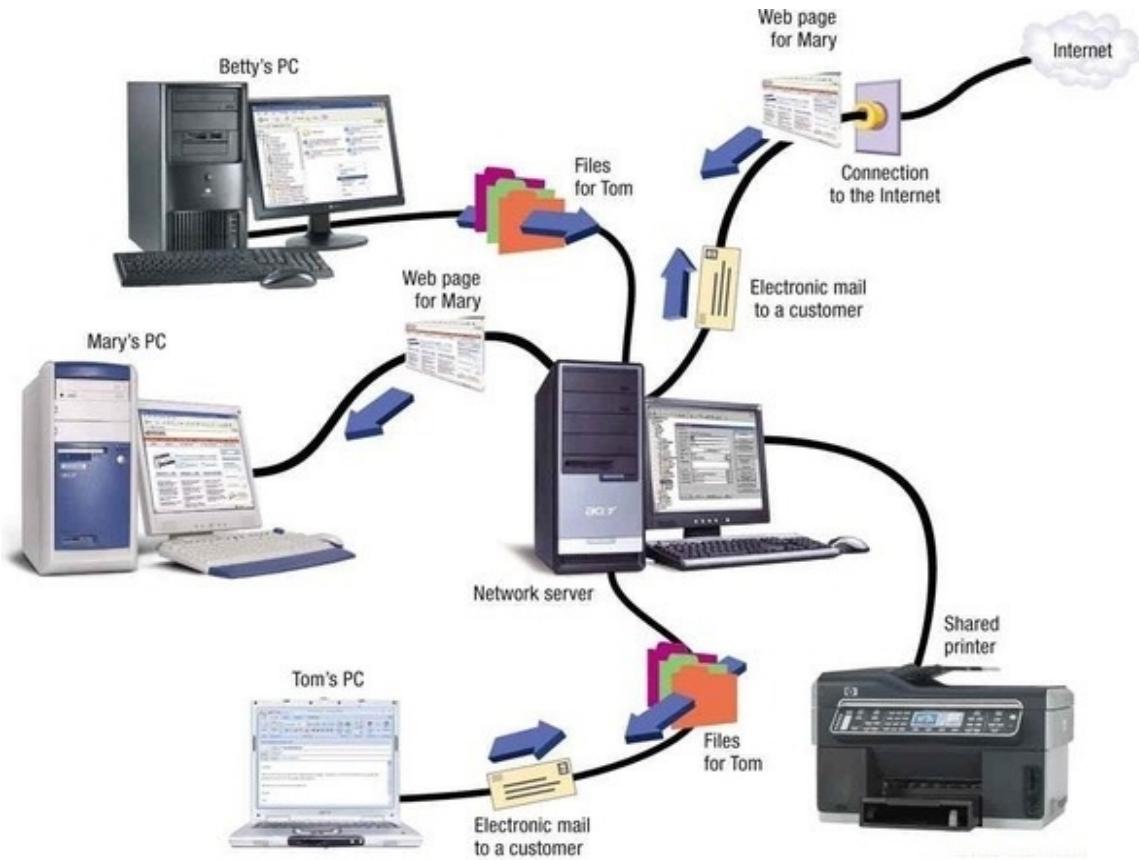
How did it start?

- 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)



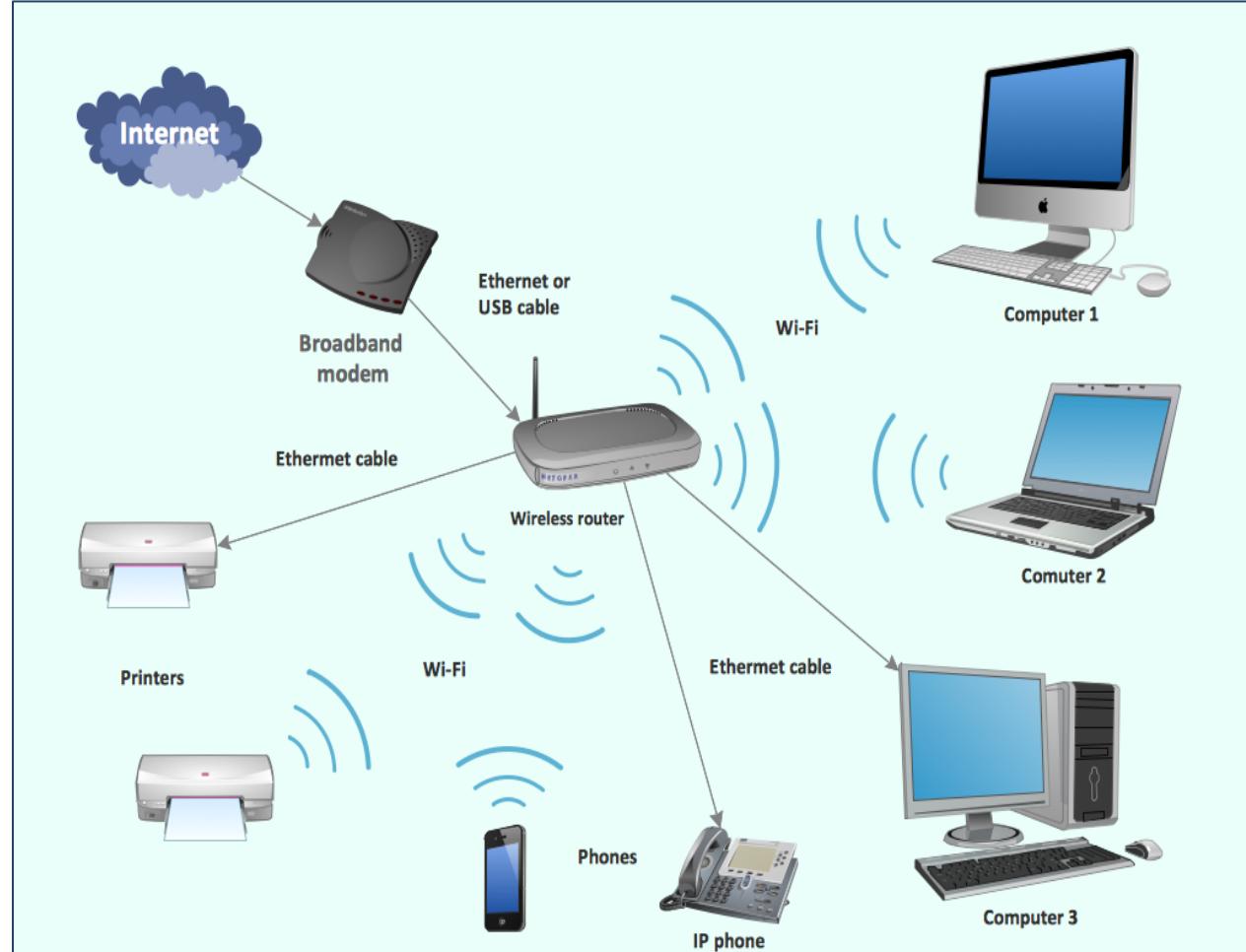
- Connects network devices over a relatively short distance
- Very useful for sharing resources such as data storage and printers

Wide Area Network (WAN)



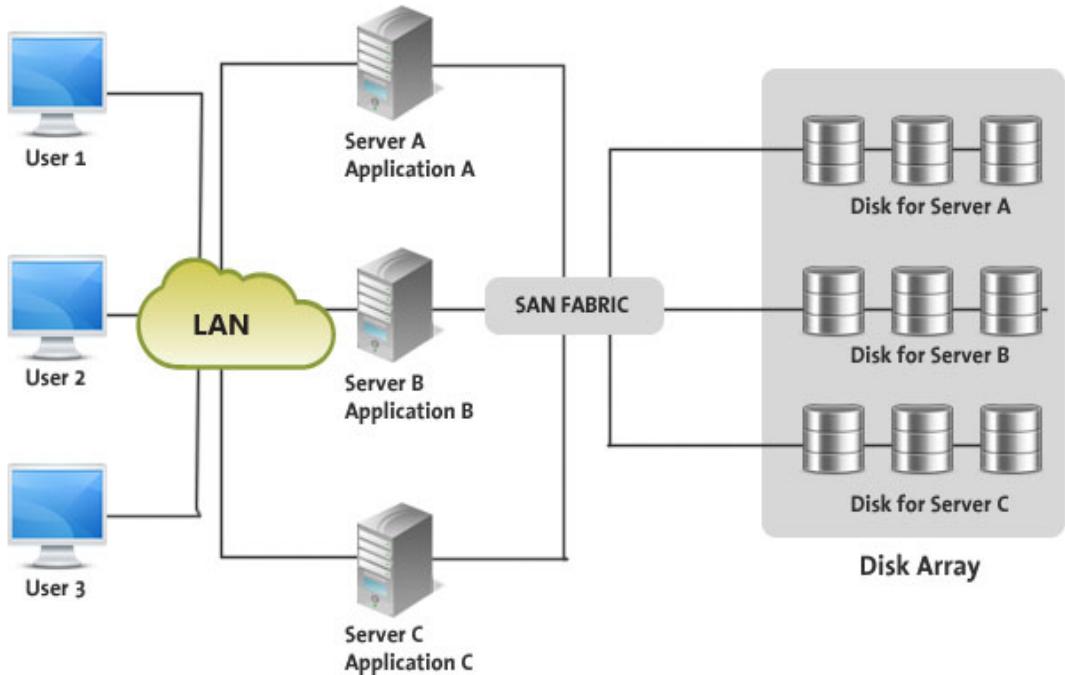
- Connects multiple LANs together
- Extends over a large geographical distance
- The **Internet** is the largest WAN spanning the Earth

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)

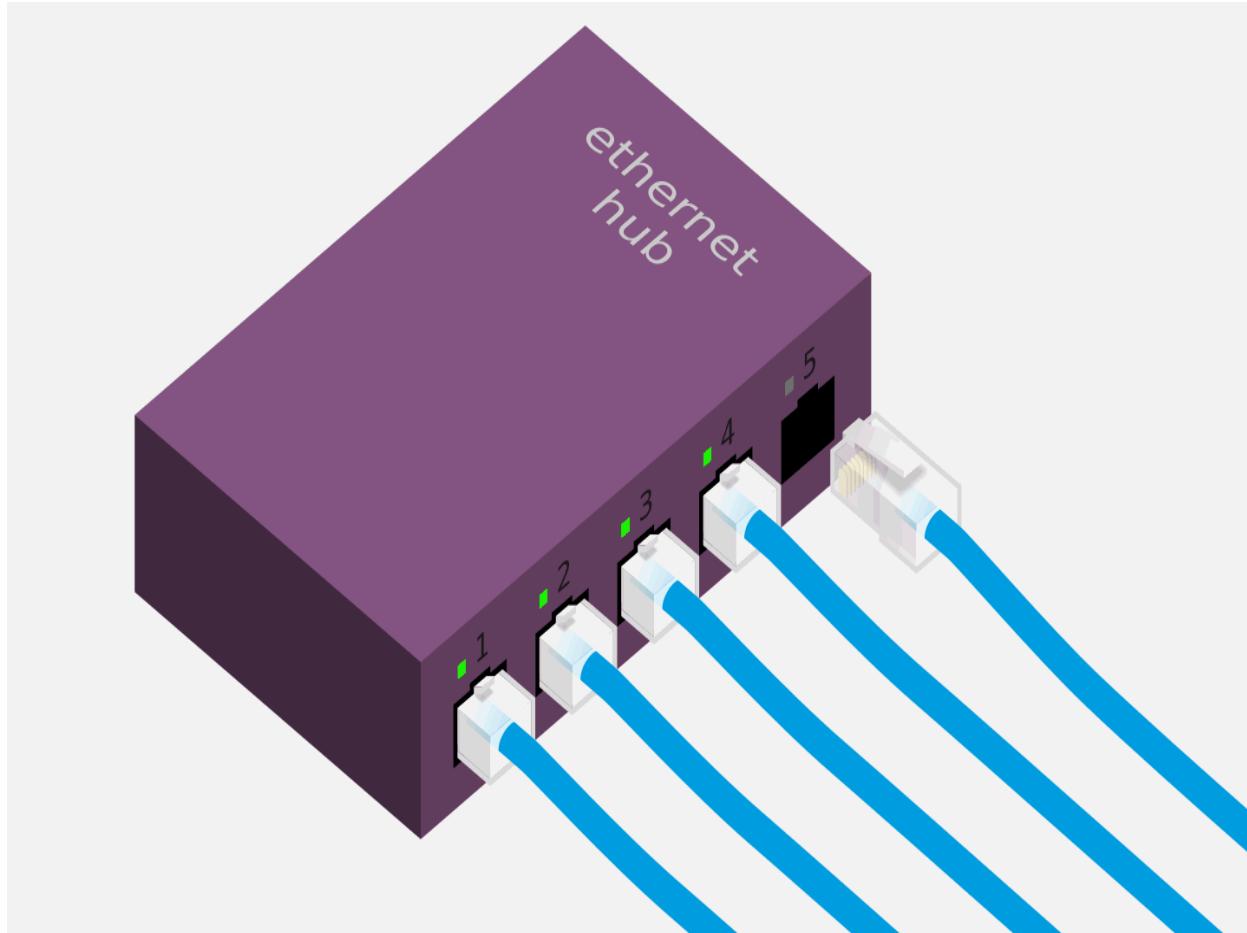
Home Area Network (HAN)



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



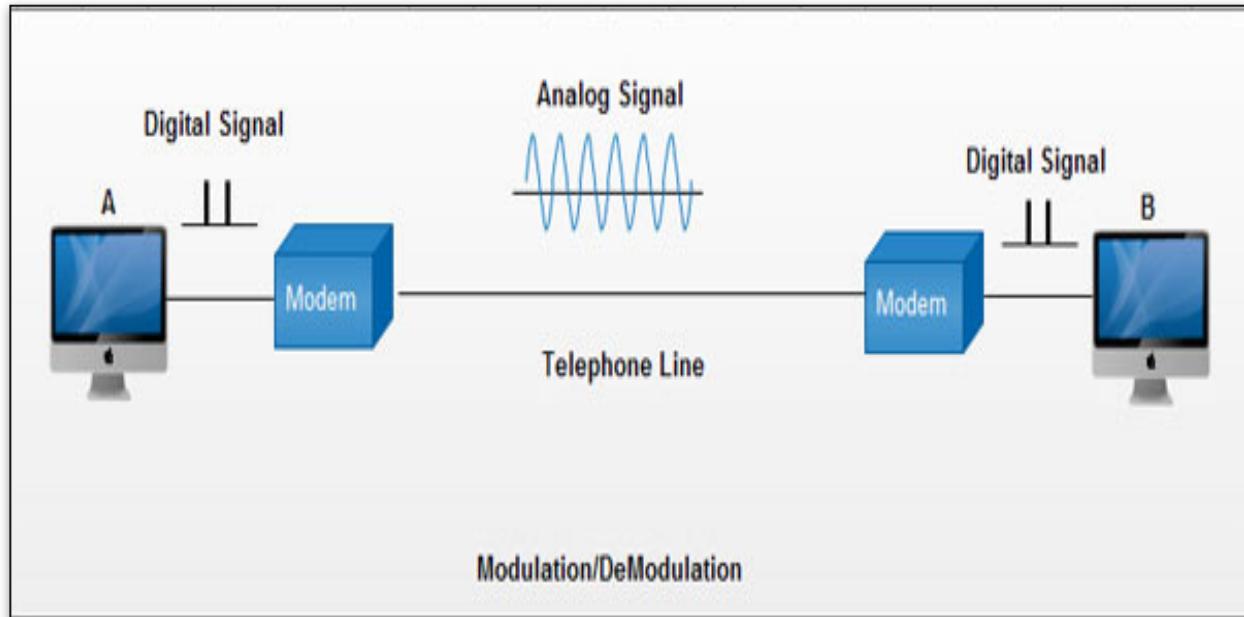
- Provides end user connectivity
- More intelligent than a hub
- Has a MAC address table
- Provides **Layer 2** functionality
(and optionally L3)
- VLANs can be configured

Router



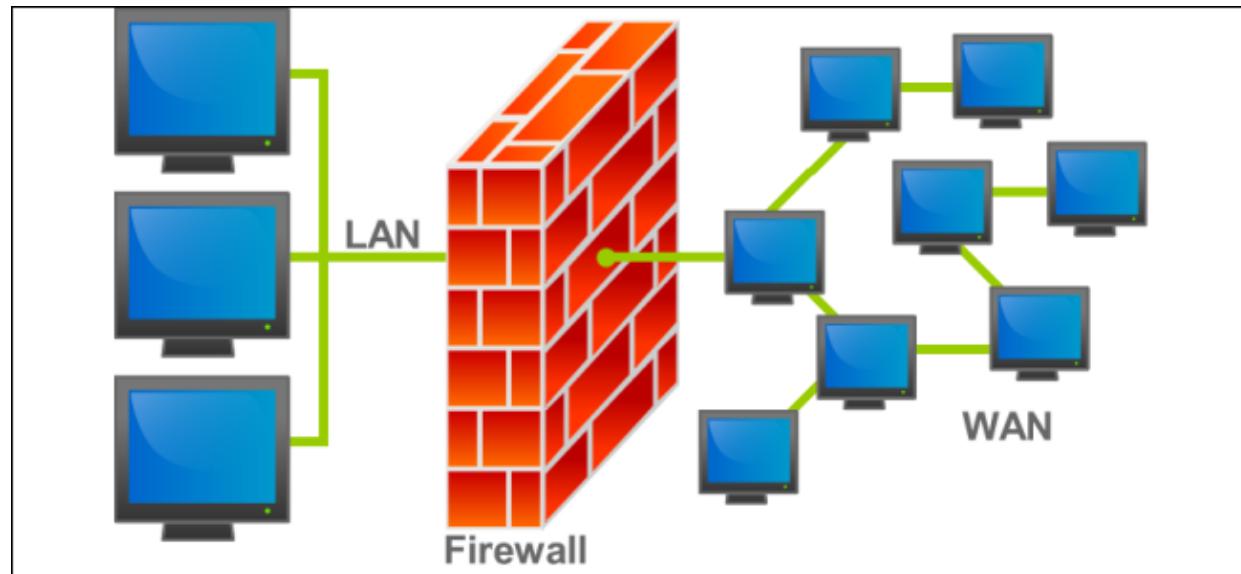
- Sends packets from one network to another
- Provides **Layer 3** functionality
- Uses IP addresses to transfer packets
- “Traffic police” - directs the network traffic to different destinations

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

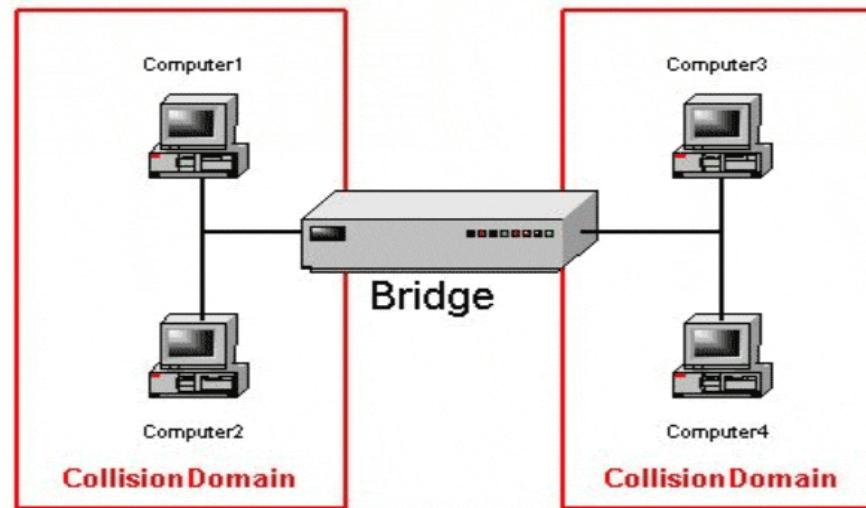
Firewall (2)



Bridge and repeater

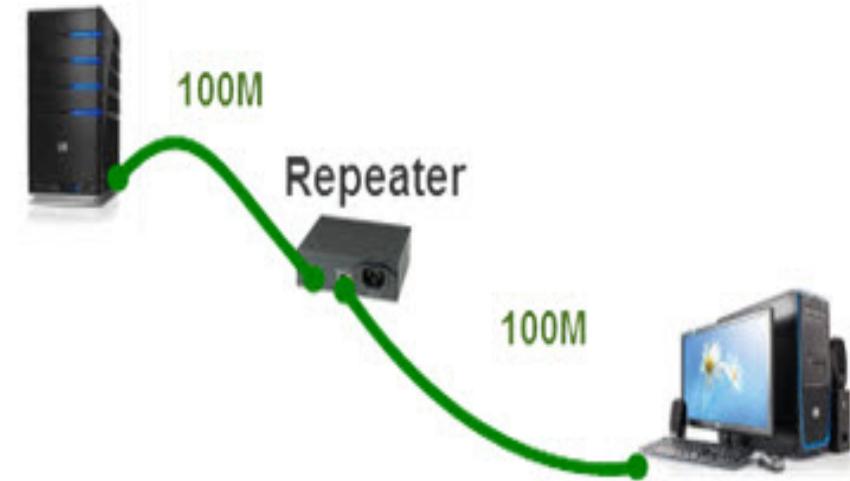
Bridge

- Similar to a Switch
- Works at Layer 2

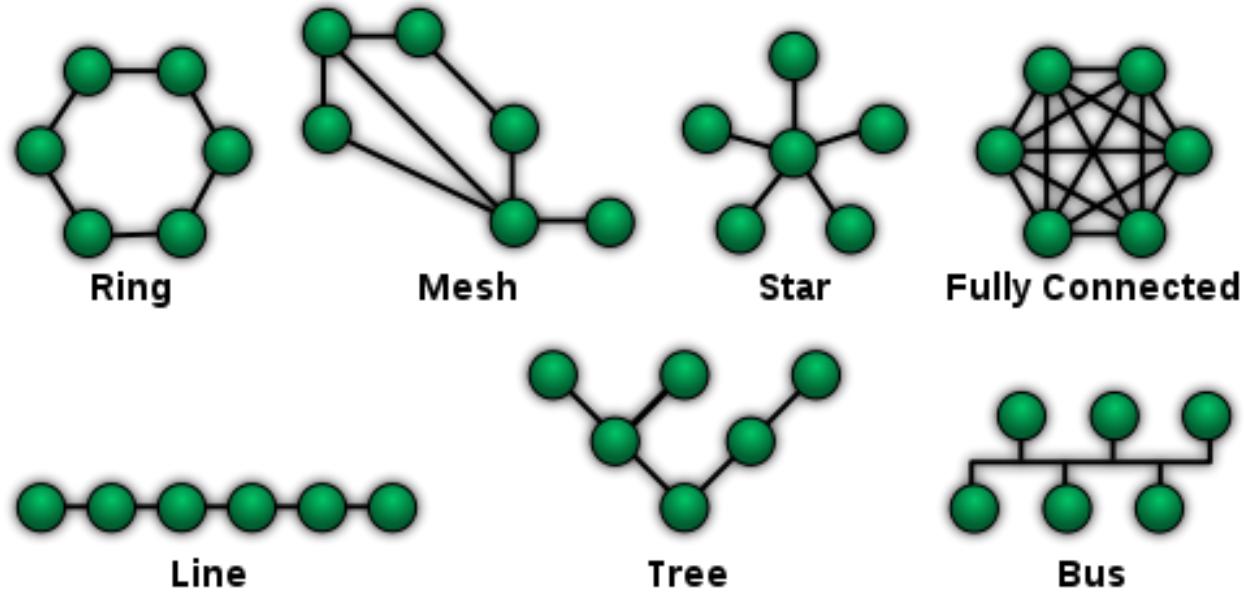


Repeater

- Similar to a Hub
- Works at Layer 1

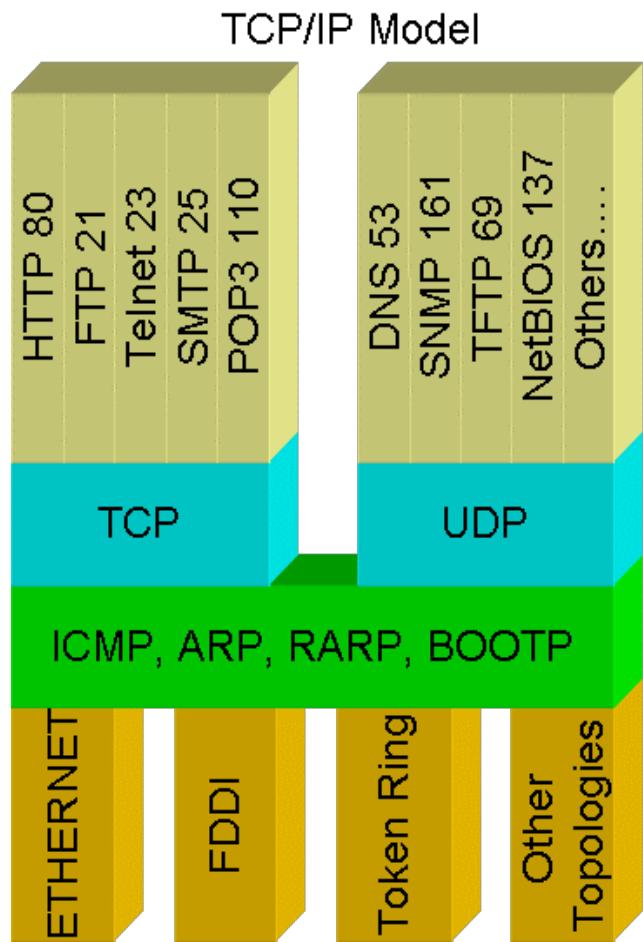


Types of Network Topologies



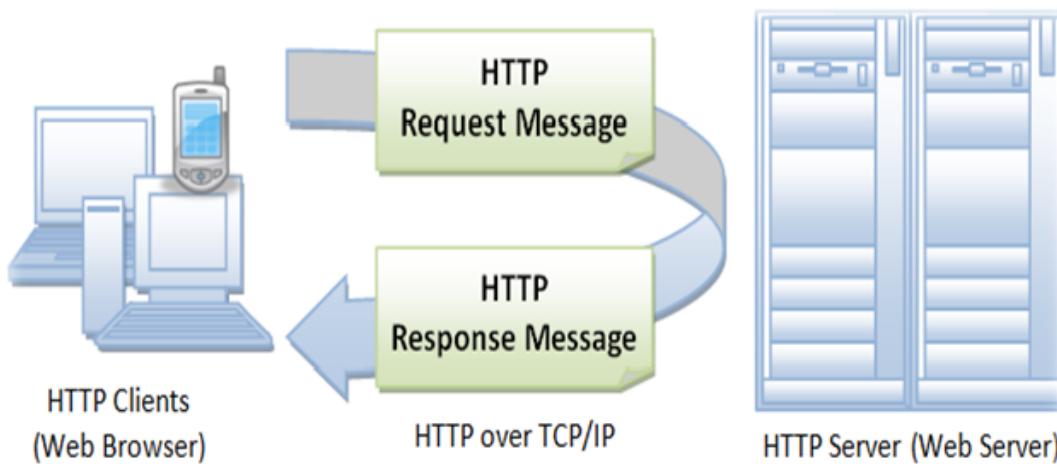
- Physical vs logical topologies
- (extended) star is the most common
- Hybrid topologies

Networks Protocols



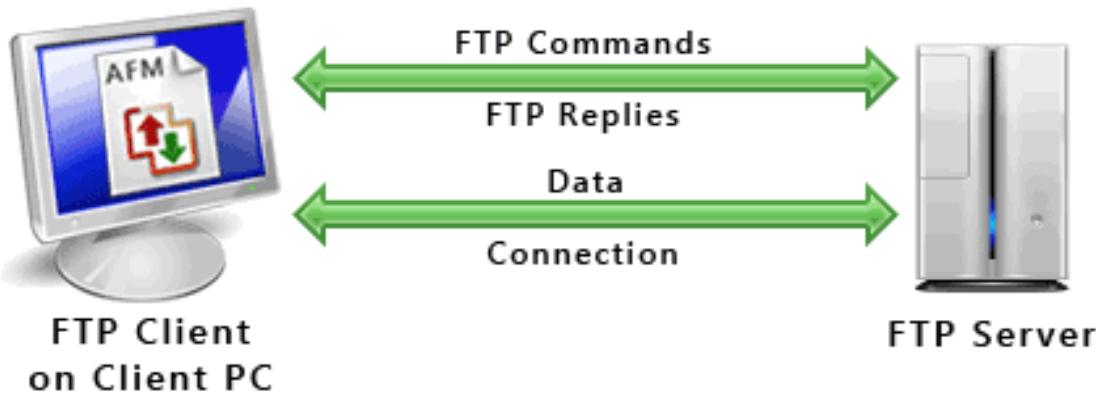
- Define a common format and set of rules for exchanging messages between network devices
- Common protocols:
 - HTTP
 - FTP
 - SMTP
 - DNS
 - DHCP
 - RDP

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)



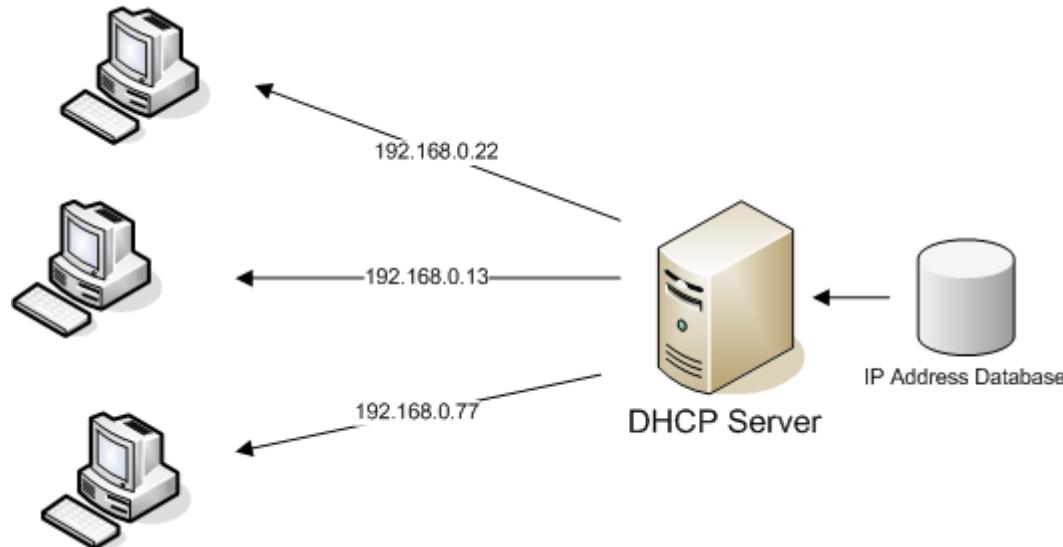
- Can be used for:
 - Server-to-server email transport
 - Client-to-server email transport

Domain Name System (DNS)



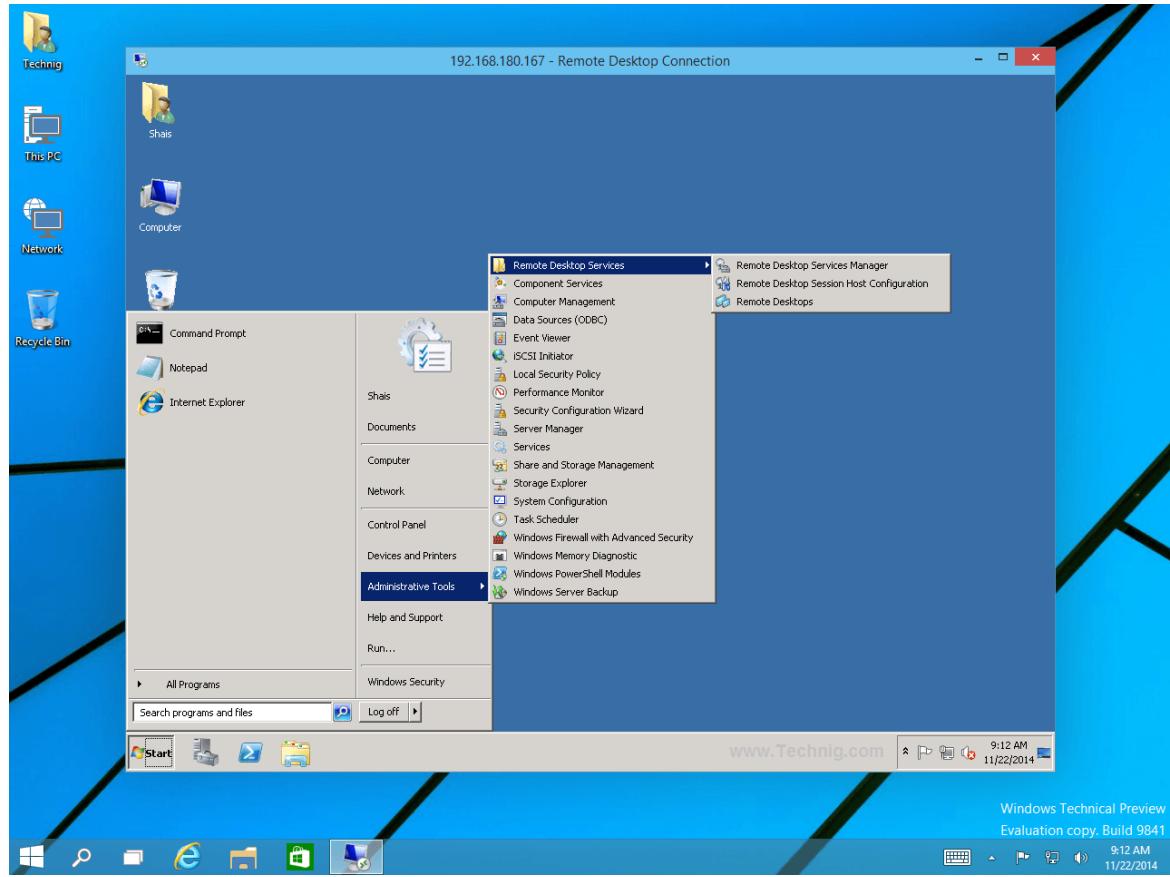
- Translates domain names into IP addresses (and much more)
- It is hierarchical and distributed database

Dynamic Host Configuration Protocol (DHCP)



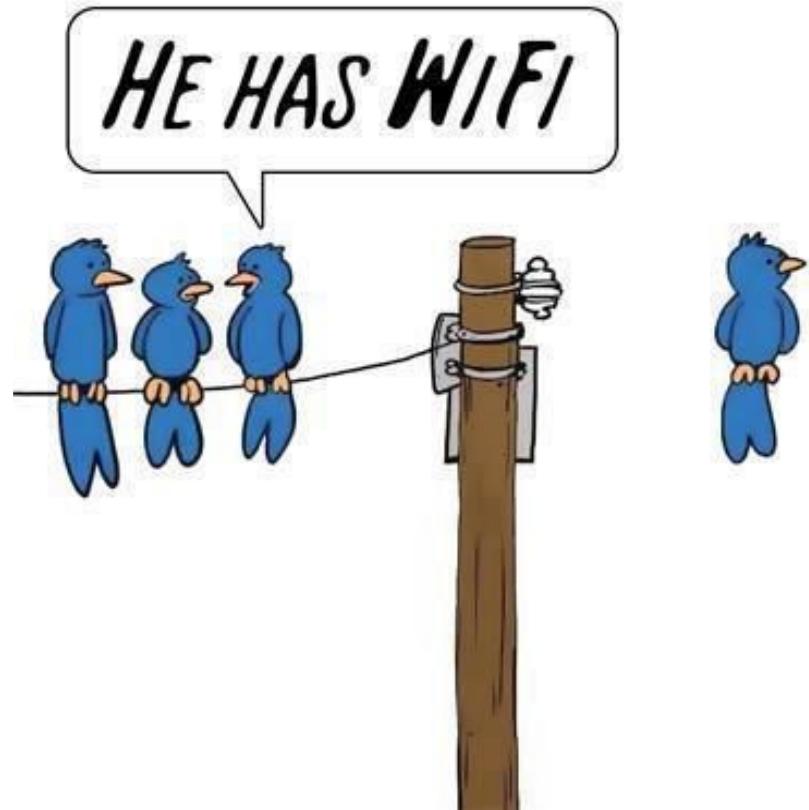
- Allows a computer to get an IP address from a special server
- Uses client-server architecture

Remote Desktop Protocol (RDP)



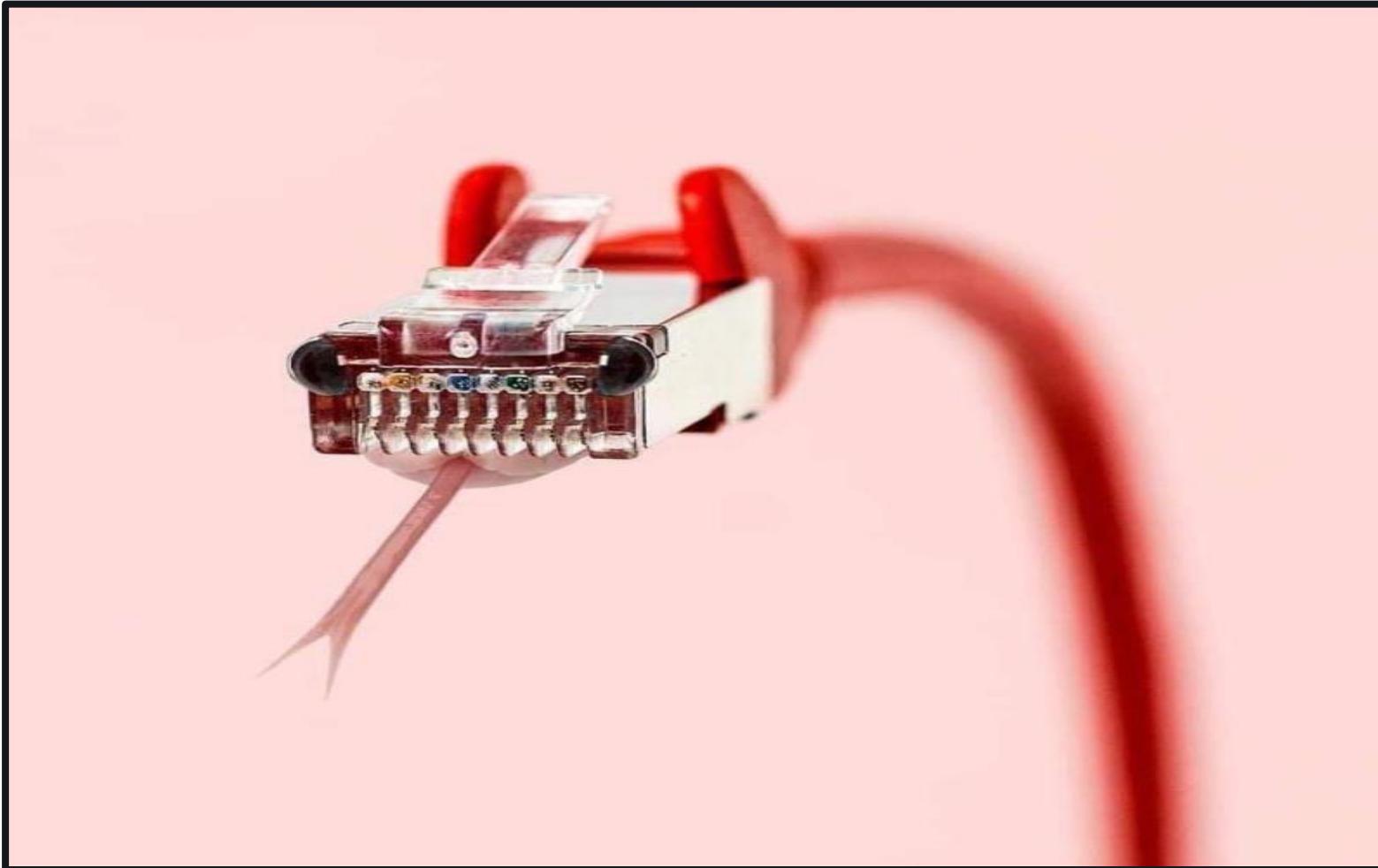
- Provides a graphical interface to connect to another computer over the network
- Can also transfer other resources between the local and remote system, like audio, disk drives and clipboard

Common Types of Media

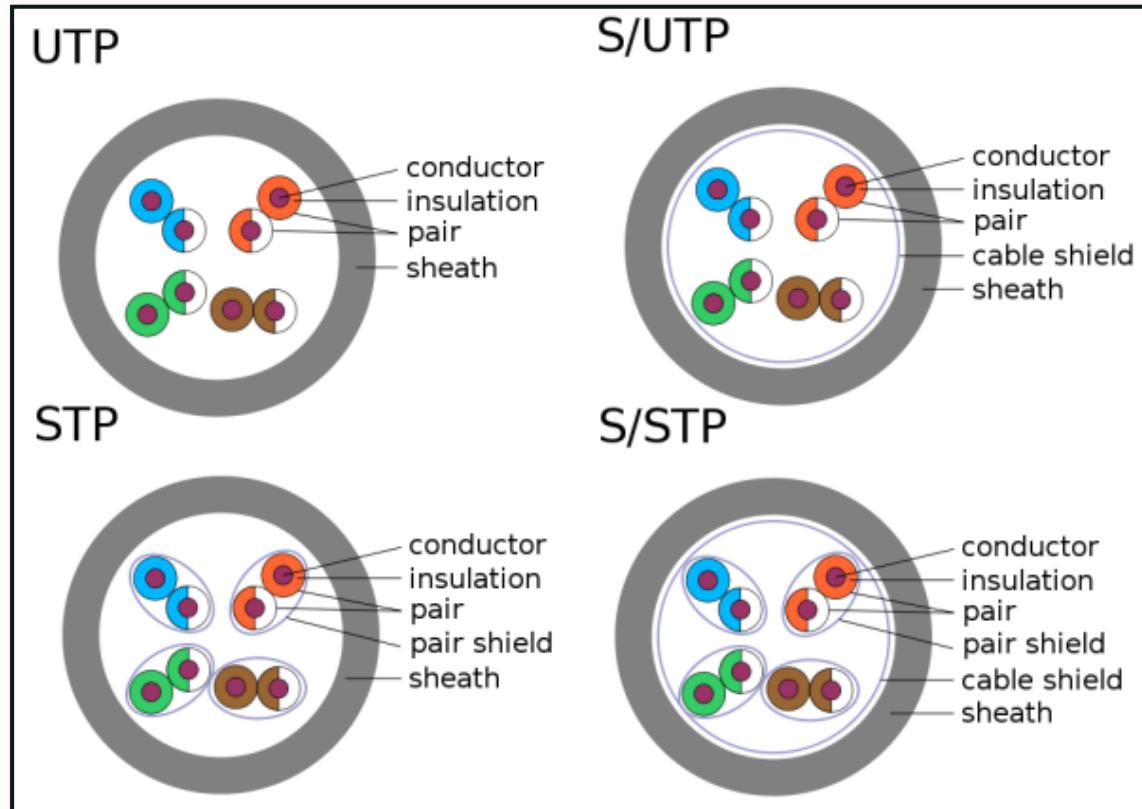


- “X”TP (“something” Twisted Pair). The “twist” idea introduced by Alexander Bell in 1881
- Coaxial Cable
- Fiber Optic
- Wireless

Let's talk about cables...

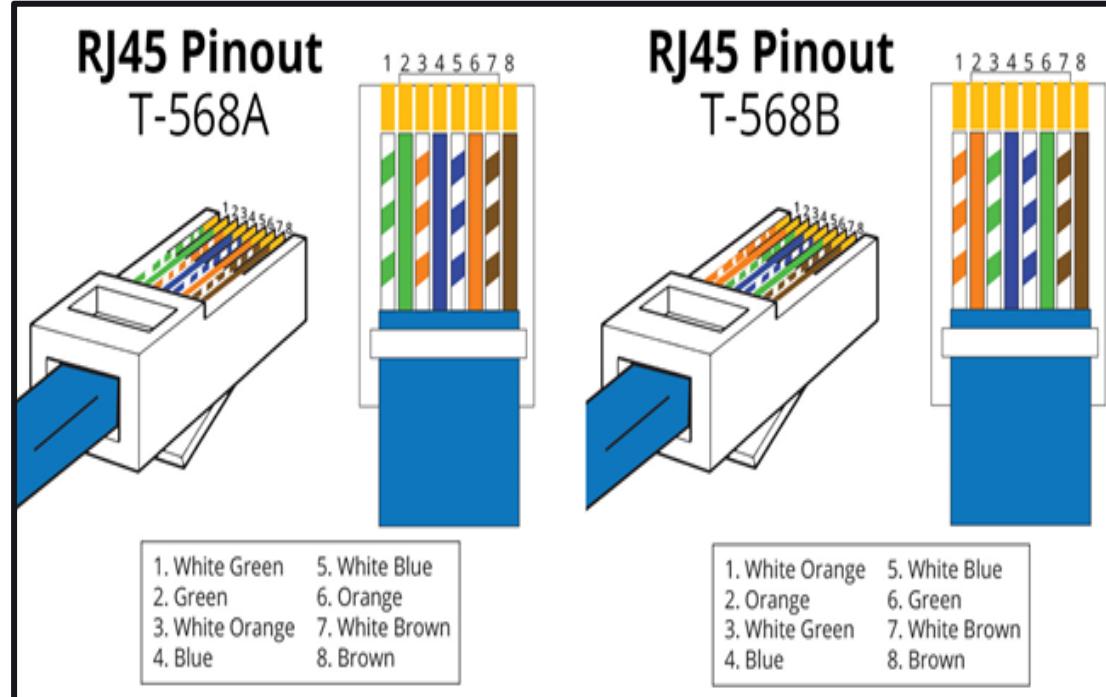


“X”TP (“something” Twisted Pair)



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

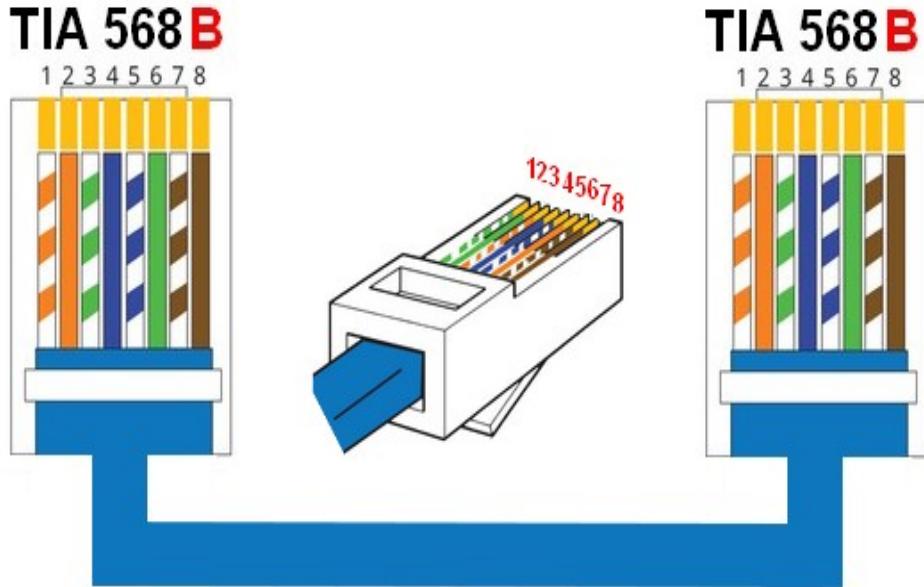
EIA/TIA Standards



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

Straight-through Cable

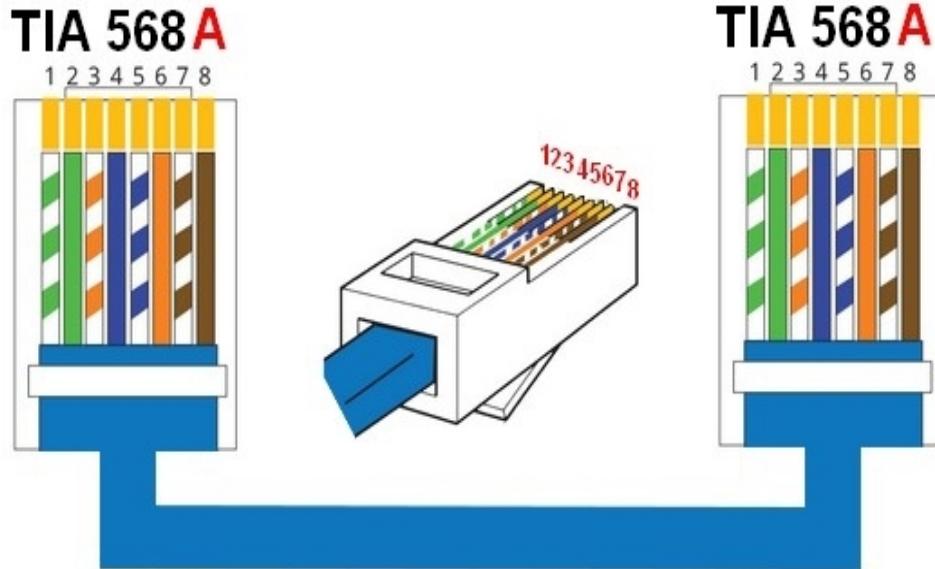
Straight Through Wiring EIA/TIA 568B



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

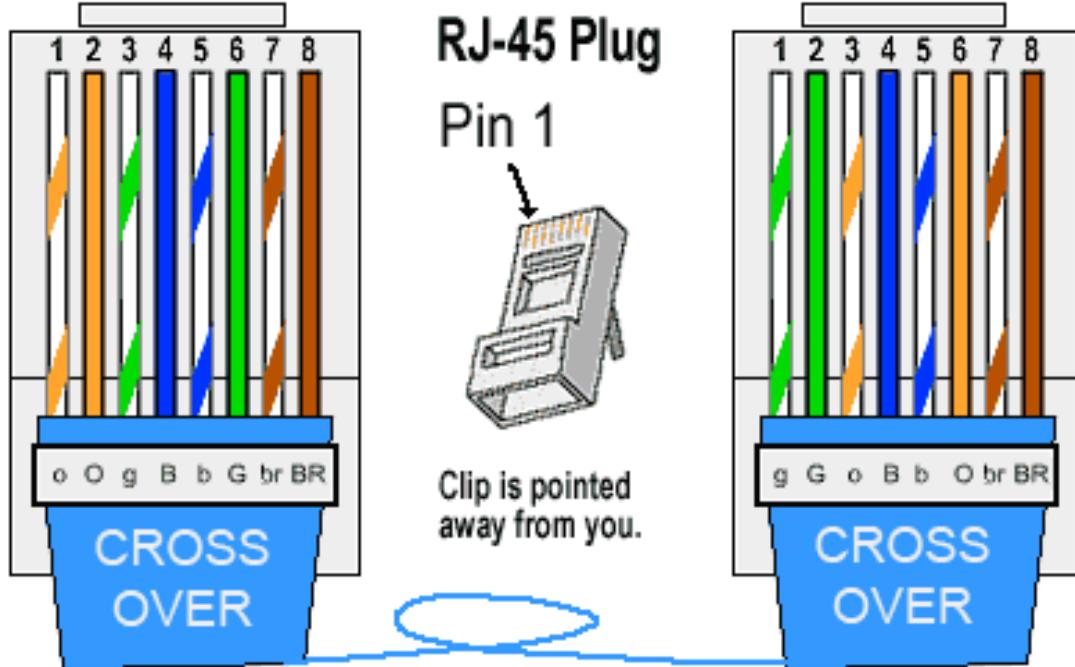
Straight-through Cable (2)

Straight Through Wiring EIA/TIA 568A



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

Crossover Cable



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

Crossover Cable (2)

TIA 568B

1 2 3 4 5 6 7 8



TIA 568A

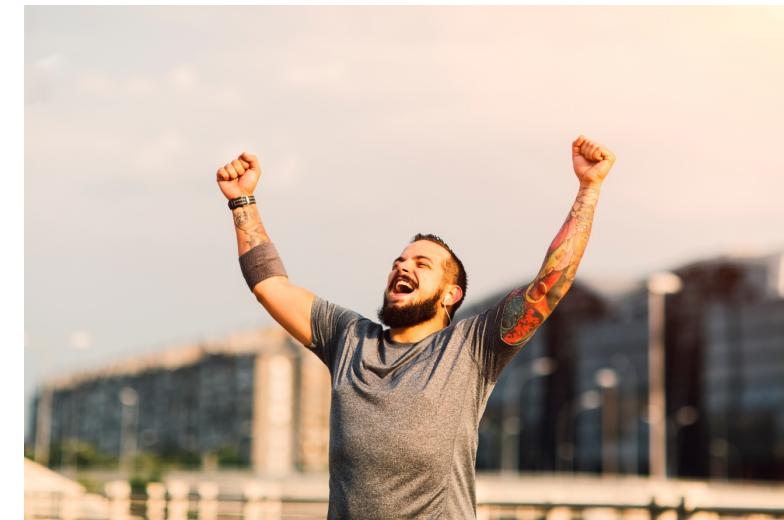
1 2 3 4 5 6 7 8



- 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

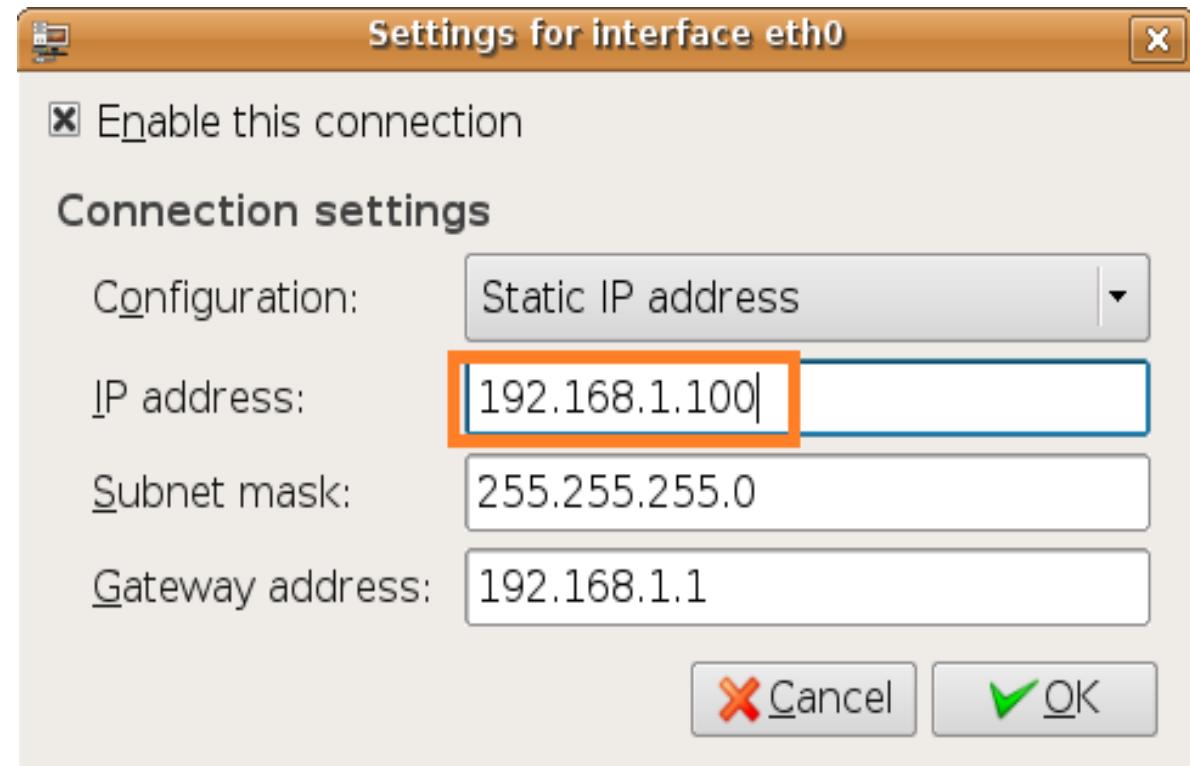
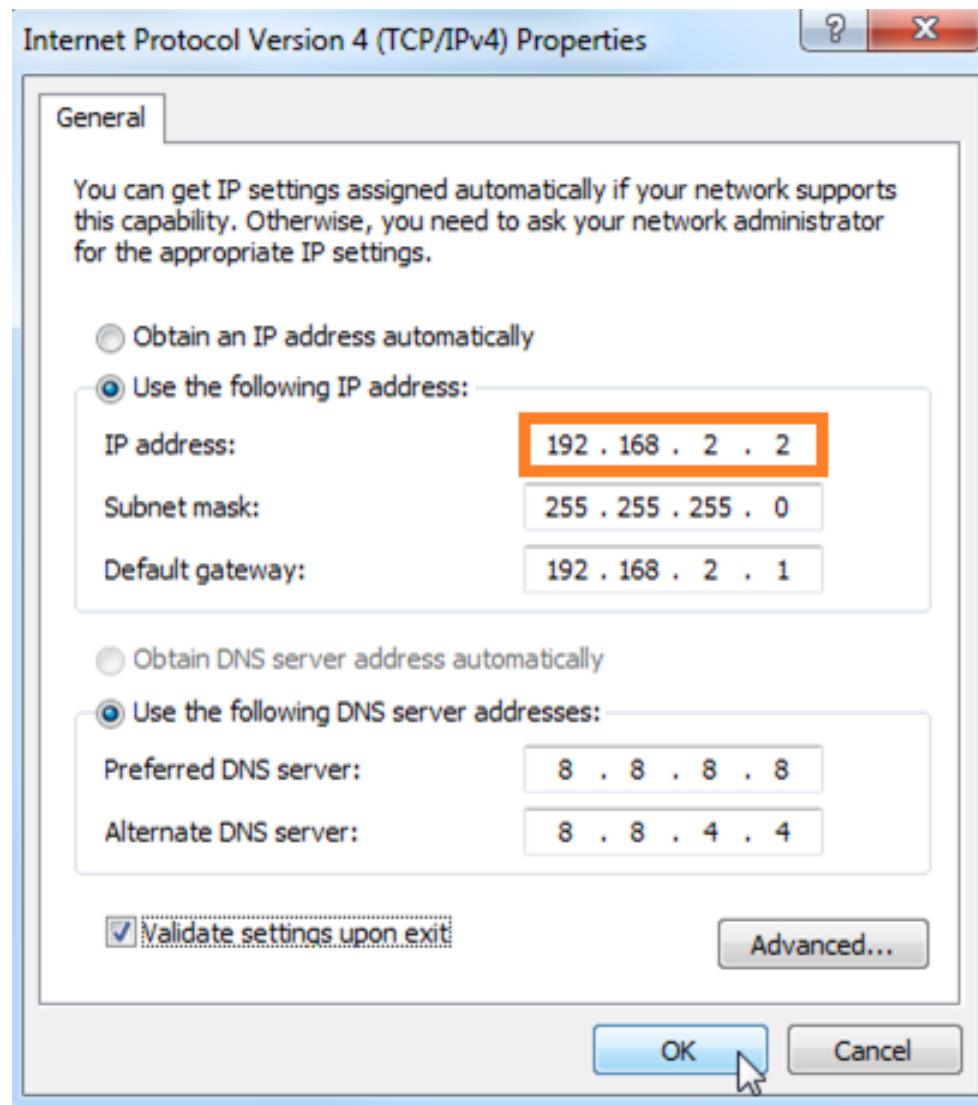


IP and MAC addresses

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

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

```
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:

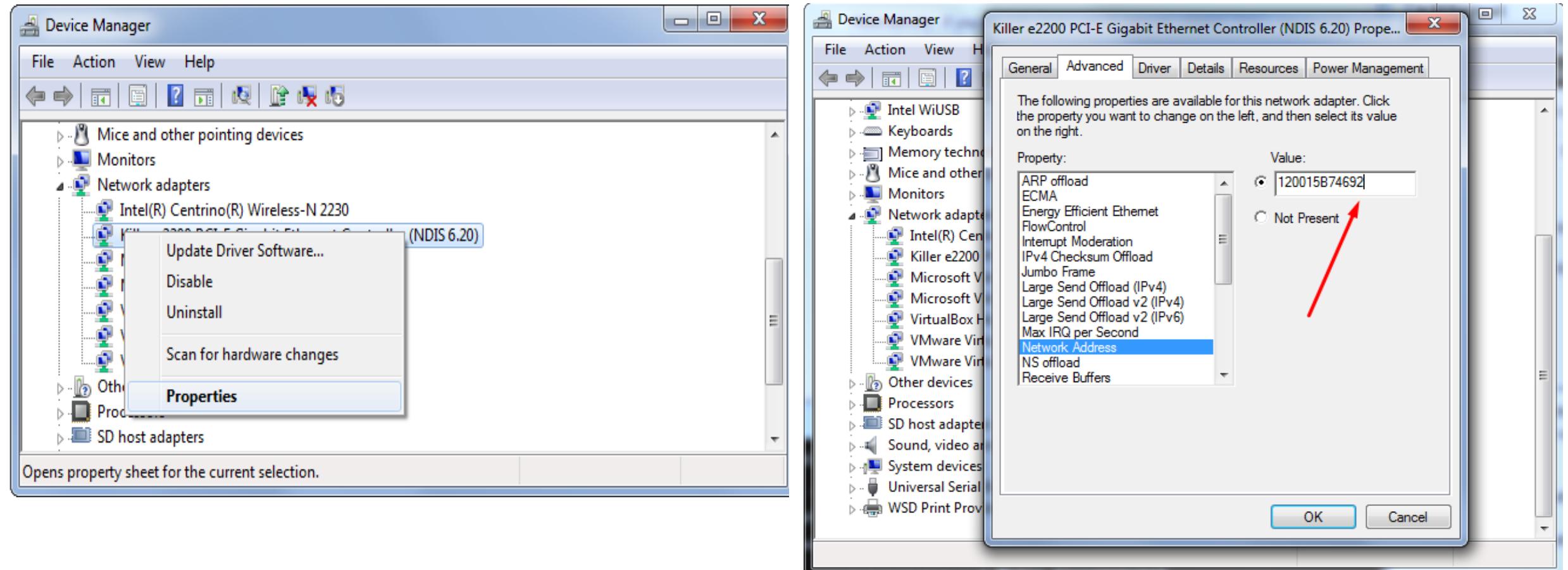
  Media State . . . . . : Media disconnected
  Connection-specific DNS Suffix . . . . . :
  Description . . . . . . . . . : Killer e2200 PCI-E Gigabit Ethernet Controller (NDIS 6.20)
  Physical Address . . . . . : 8C-89-A5-02-93-AF
  DHCP Enabled. . . . . : Yes
  Autoconfiguration Enabled . . . . . : Yes
```

Linux

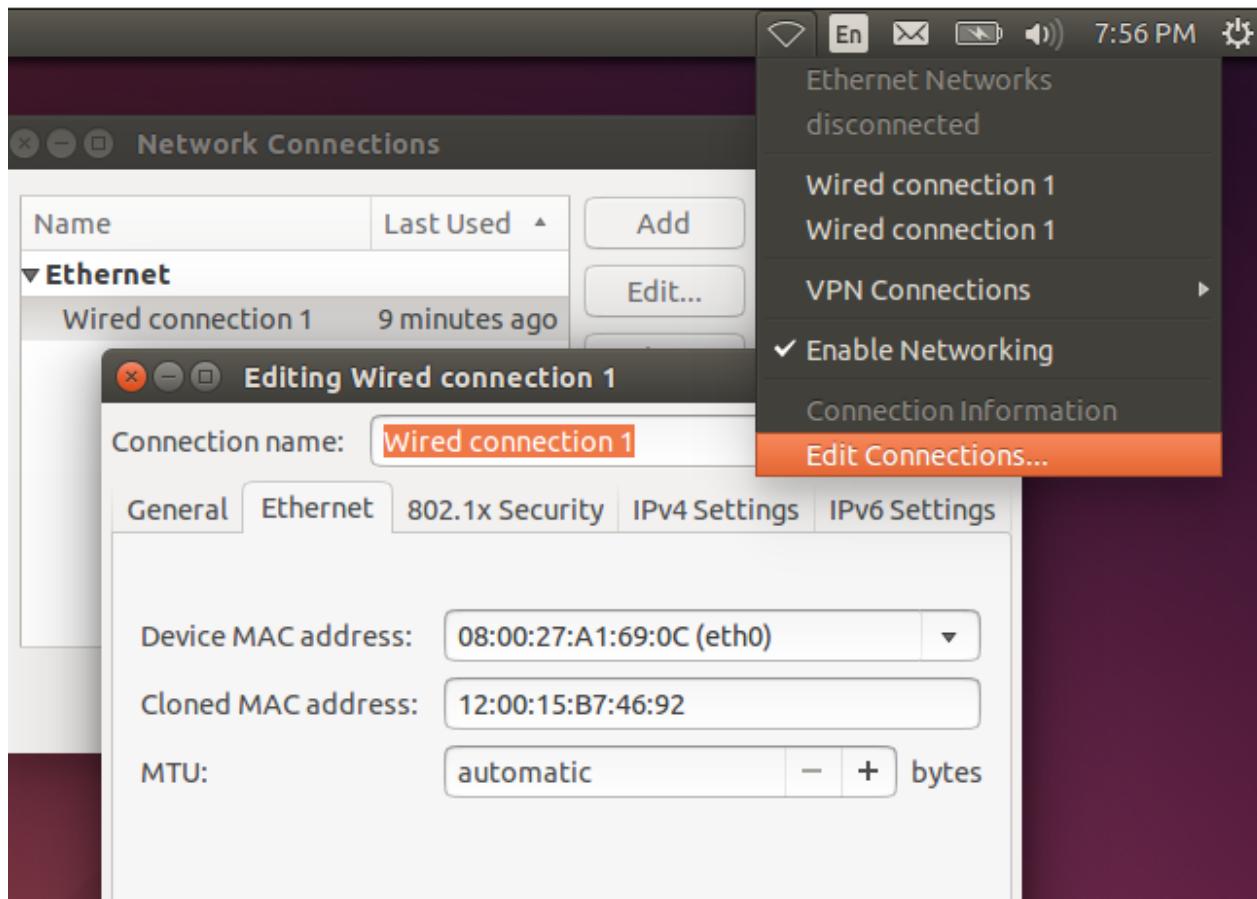
```
ubuntu@ubuntu:~$ ifconfig -a
eth0      Link encap:Ethernet HWaddr 08:00:27:62:bf:e1
          inet addr:10.0.2.15 Bcast:10.0.2.255 Mask:255.255.255.0
          inet6 addr: fe80::a00:27ff:fe62:bfe1/64 Scope:Link
          UP BROADCAST RUNNING MULTICAST MTU:1500 Metric:1
          RX packets:60 errors:0 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



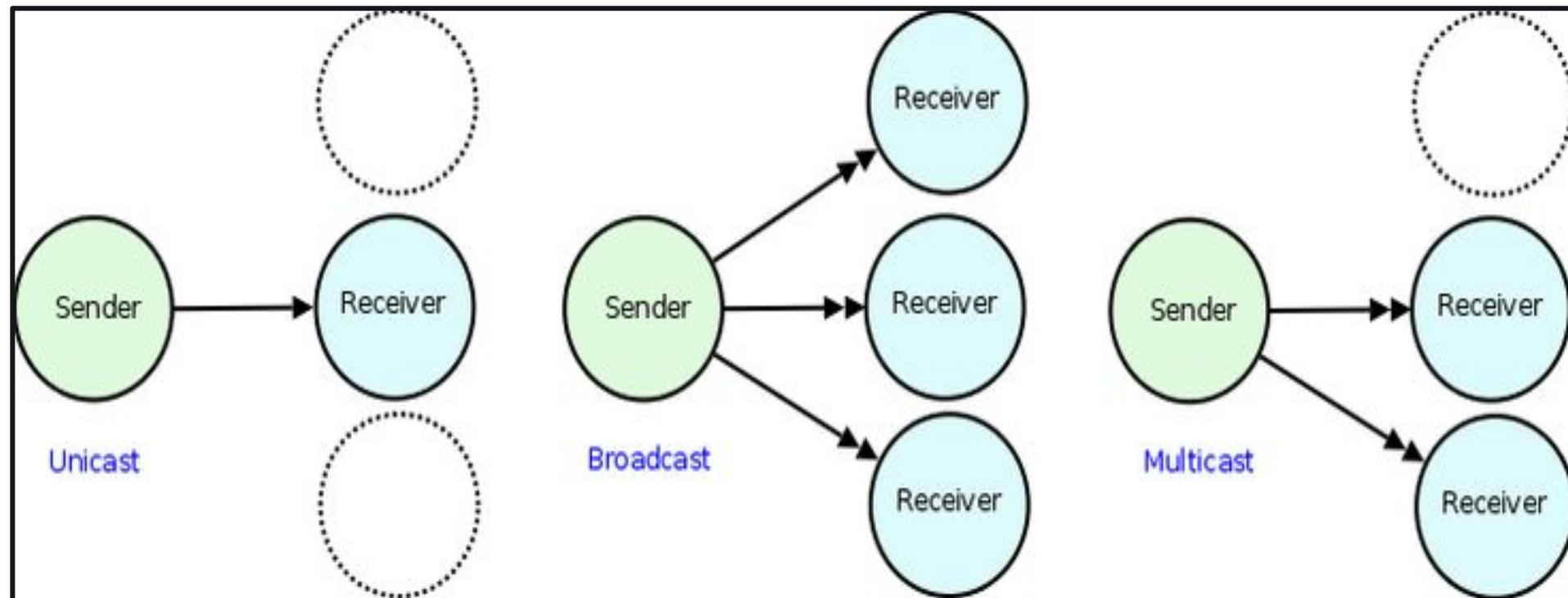
The terminal window shows the command sequence used to change the MAC address:

```
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:~$
```

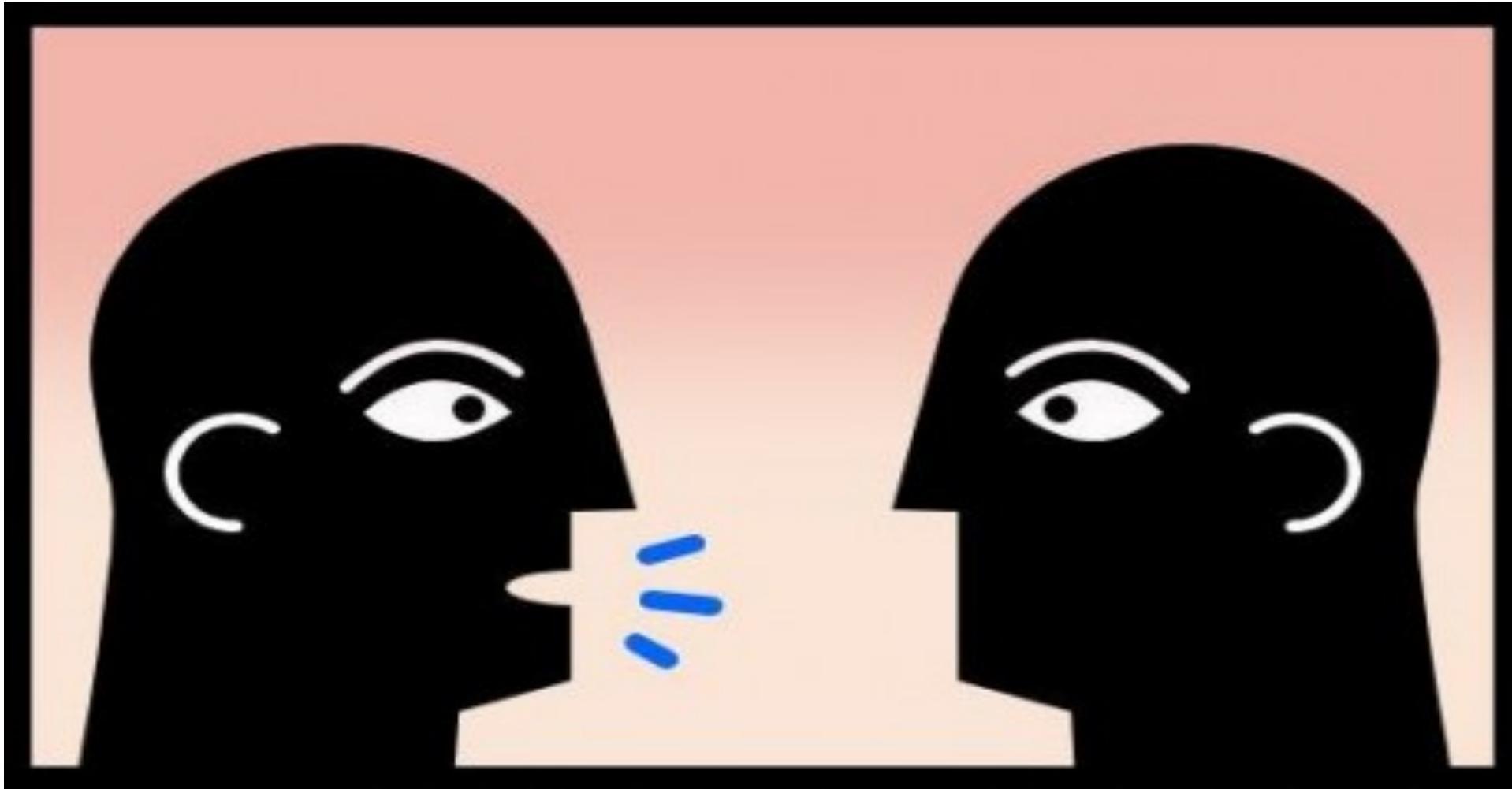
The new MAC address

Traffic Types

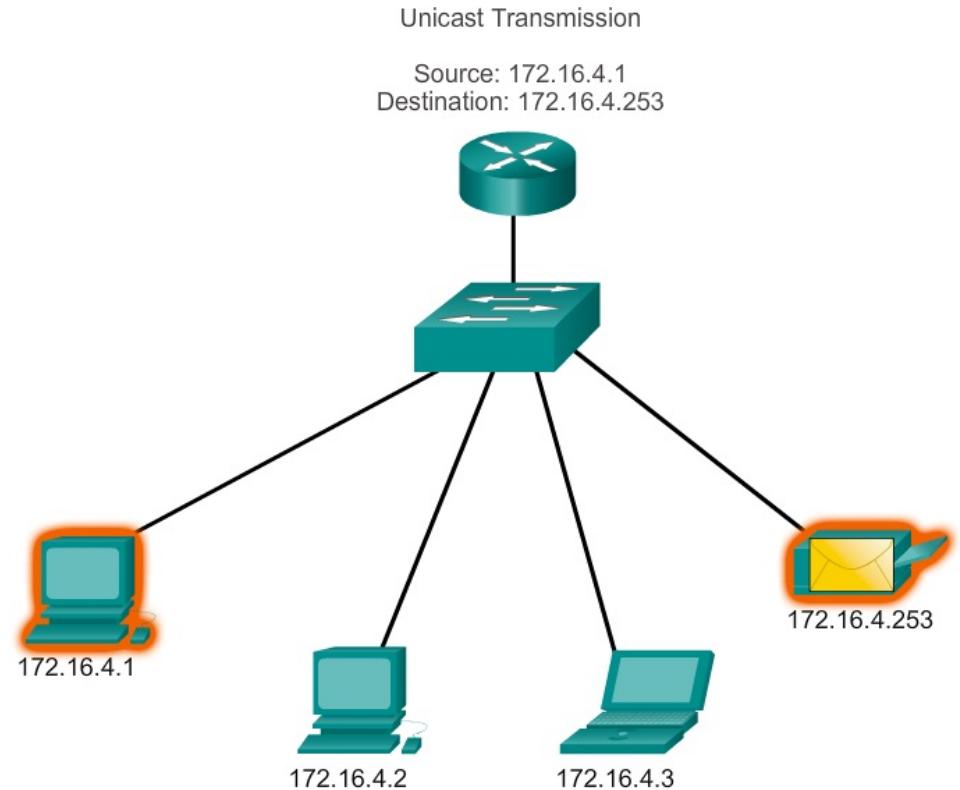
Types of traffic



Unicast



Unicast (2)



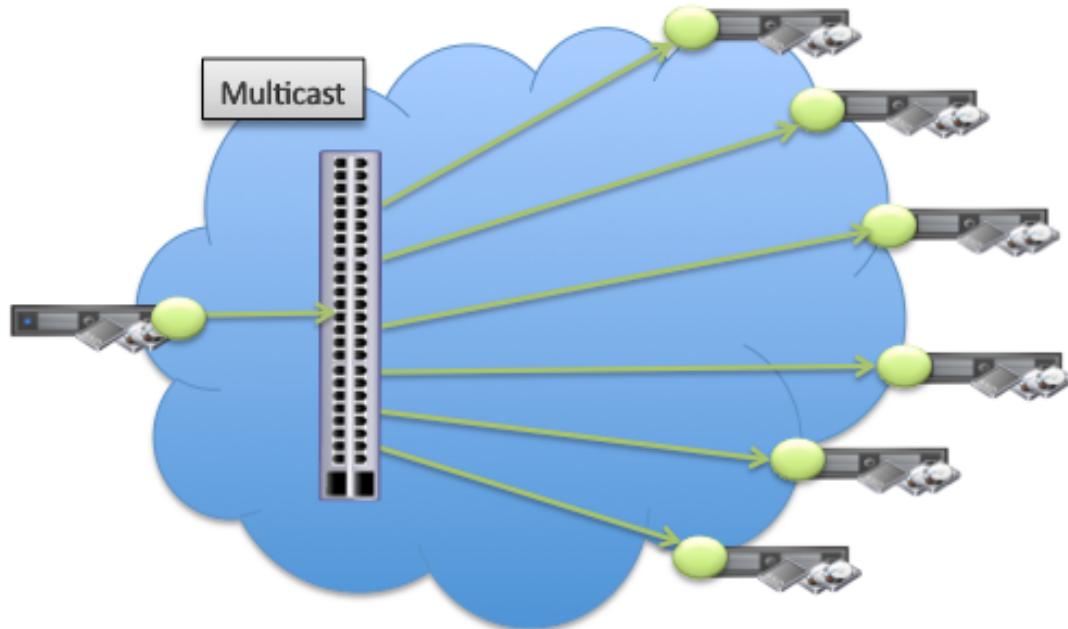
- Single destination identified by a unique address
- Used in host-to-host or host-to-server communication

Broadcast



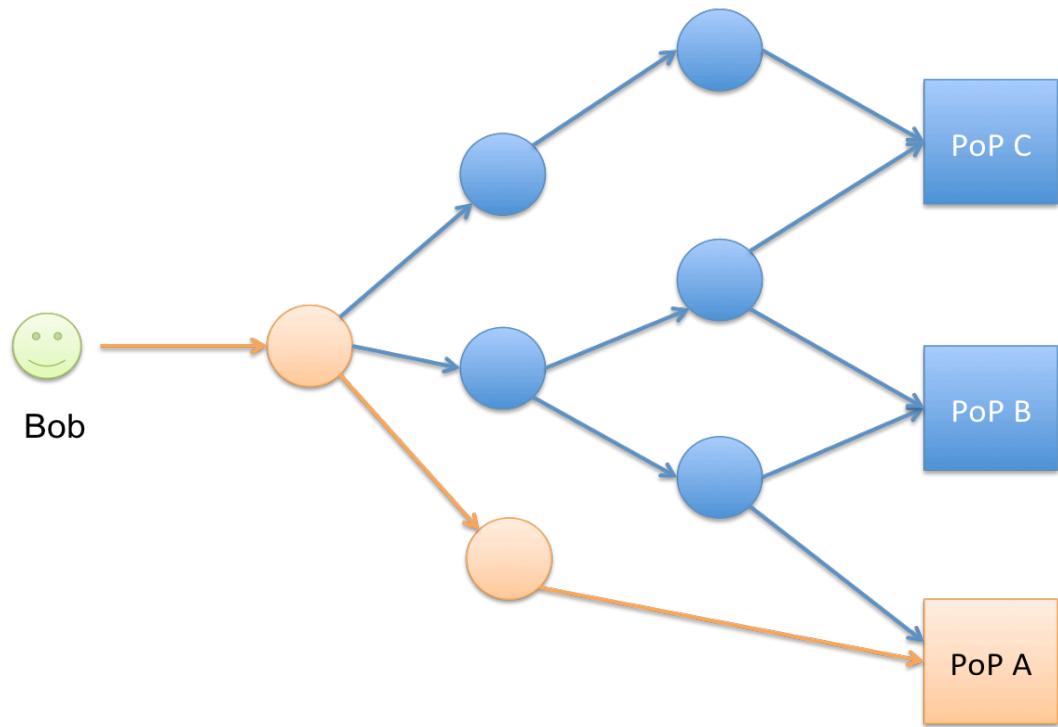
- Send a message to **all** recipients simultaneously
- Used in DHCP, ARP
(will be discussed later)

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

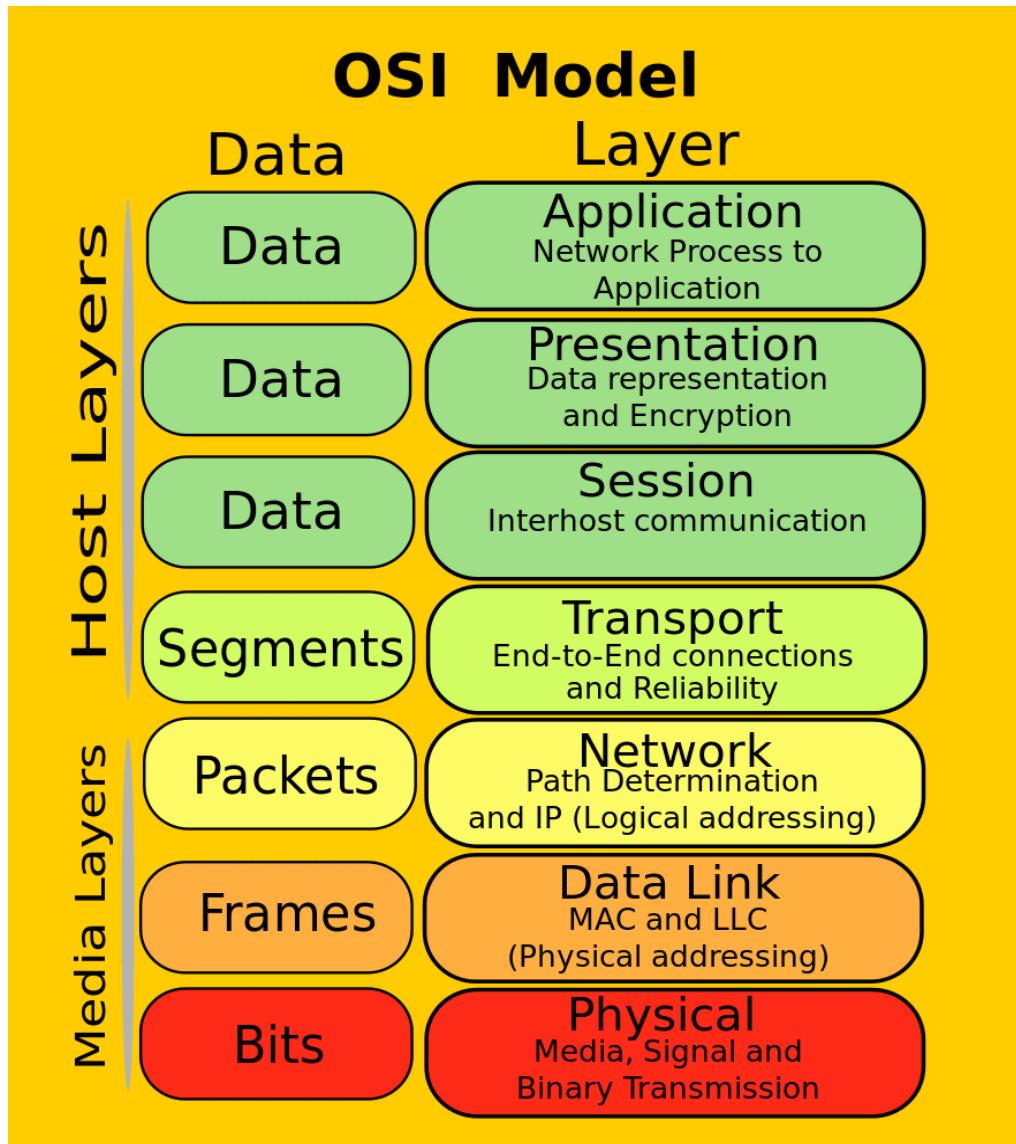
Anycast



- 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

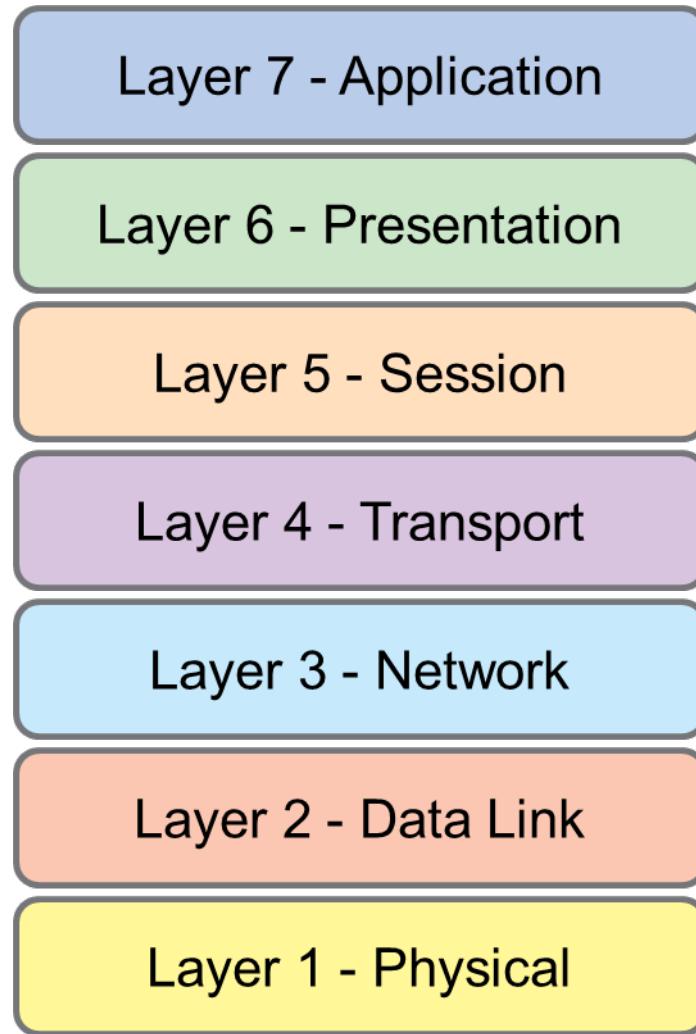
OSI and TCP/IP models

OSI Model



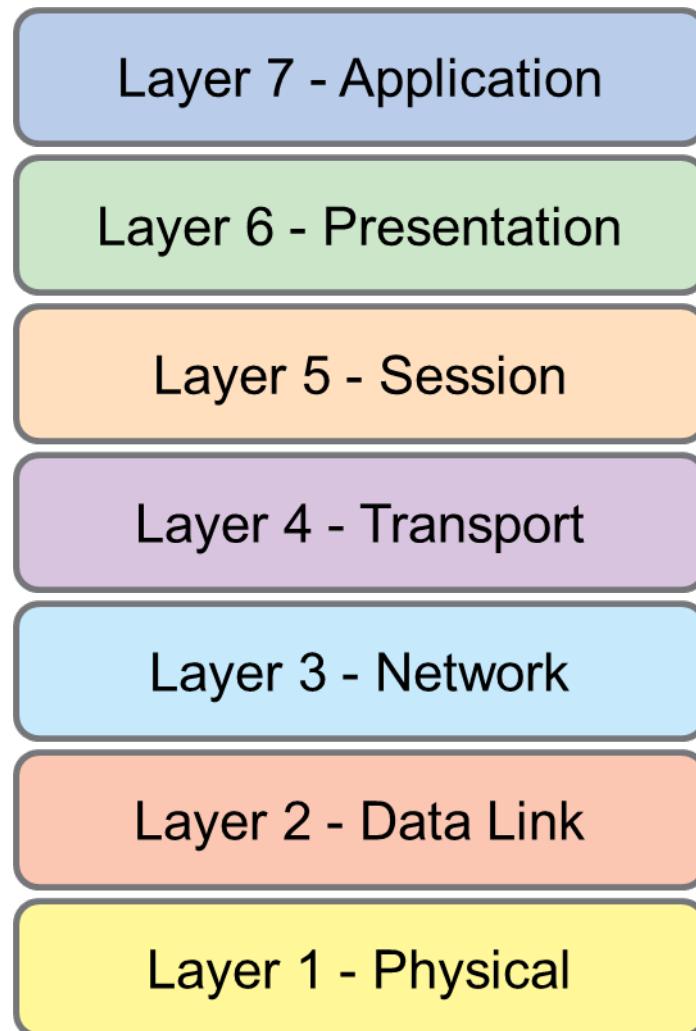
- OSI = Open Systems Interconnection
- Why?
 - Organizes the information
 - Simplifies learning
 - Standards for the vendors
 - Easier troubleshooting
- Protocol Data Unit (PDU) – different data format at each layer

Layer 1 - Physical



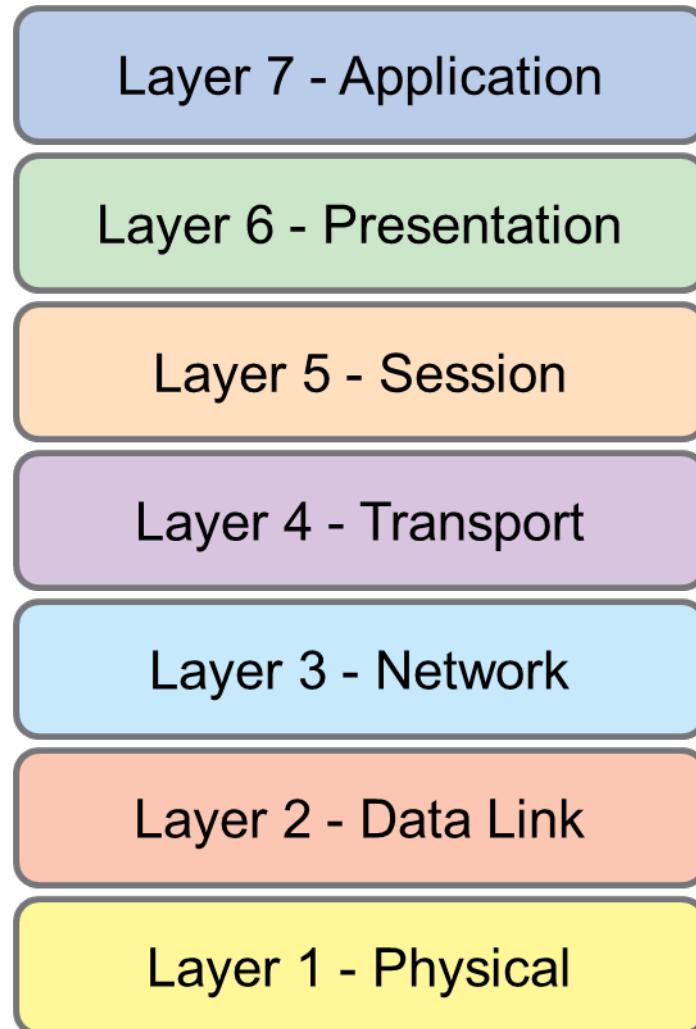
- The first and lowest layer
- Transmitting raw bits
- Wiring standards
- Devices: hubs, repeaters, modems, cabling, connectors
- Protocols: USB, Infrared, Bluetooth

Layer 2 – Data Link



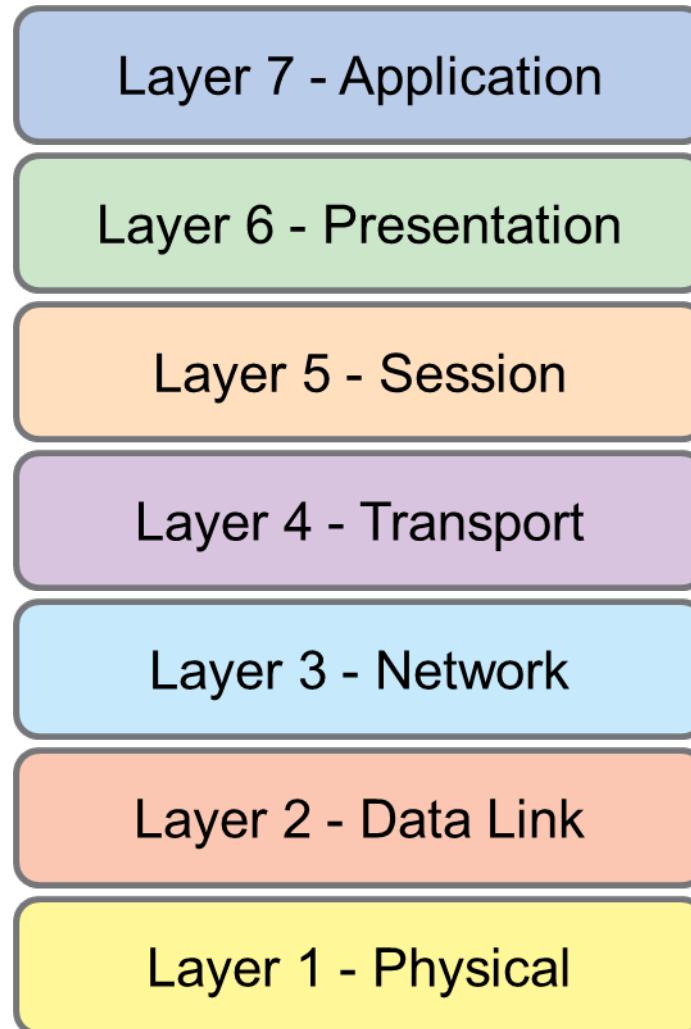
- Switching functions
- MAC addresses
- Devices: switch, bridge, NIC
- Protocols: **VLAN**, ARP, LLDP, CDP, STP

Layer 3 – Network



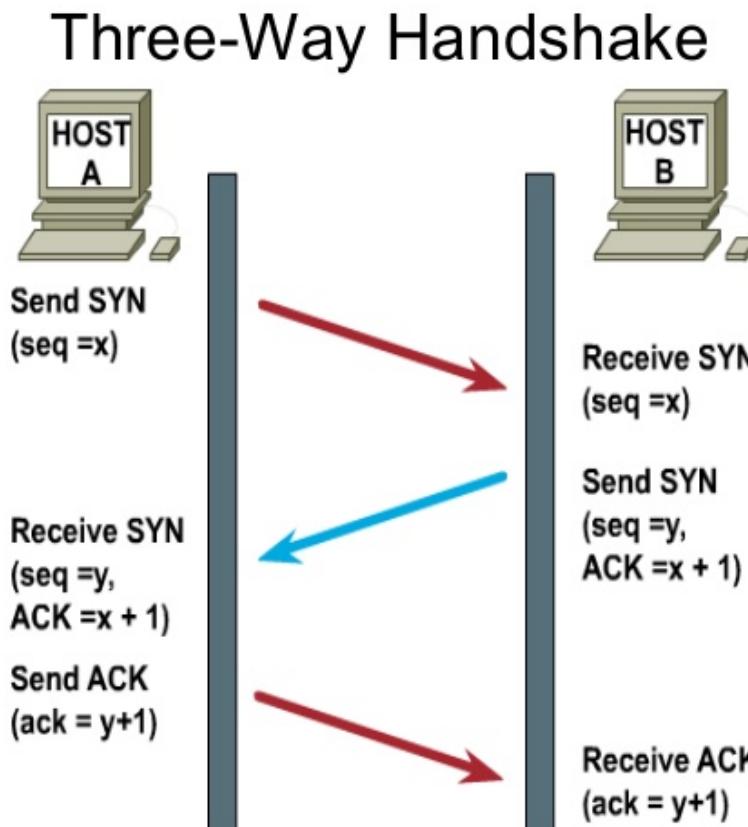
- Routing functions
- IP addresses
- Devices: router, L3 switch
- Protocols: IP, ICMP (ping), RIP, OSPF, EIGRP, GRE, etc.

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



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 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?

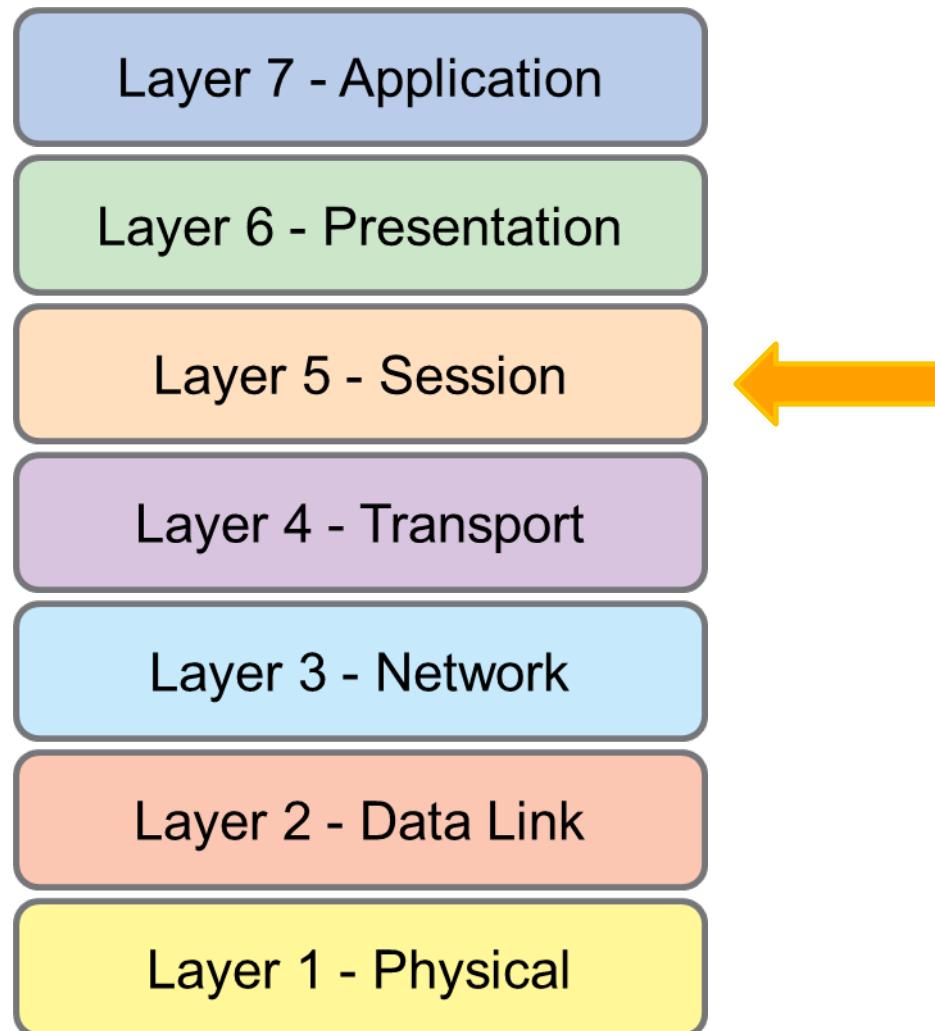


jkjustjoshing 5 months ago
I have received the joke about TCP/IP.



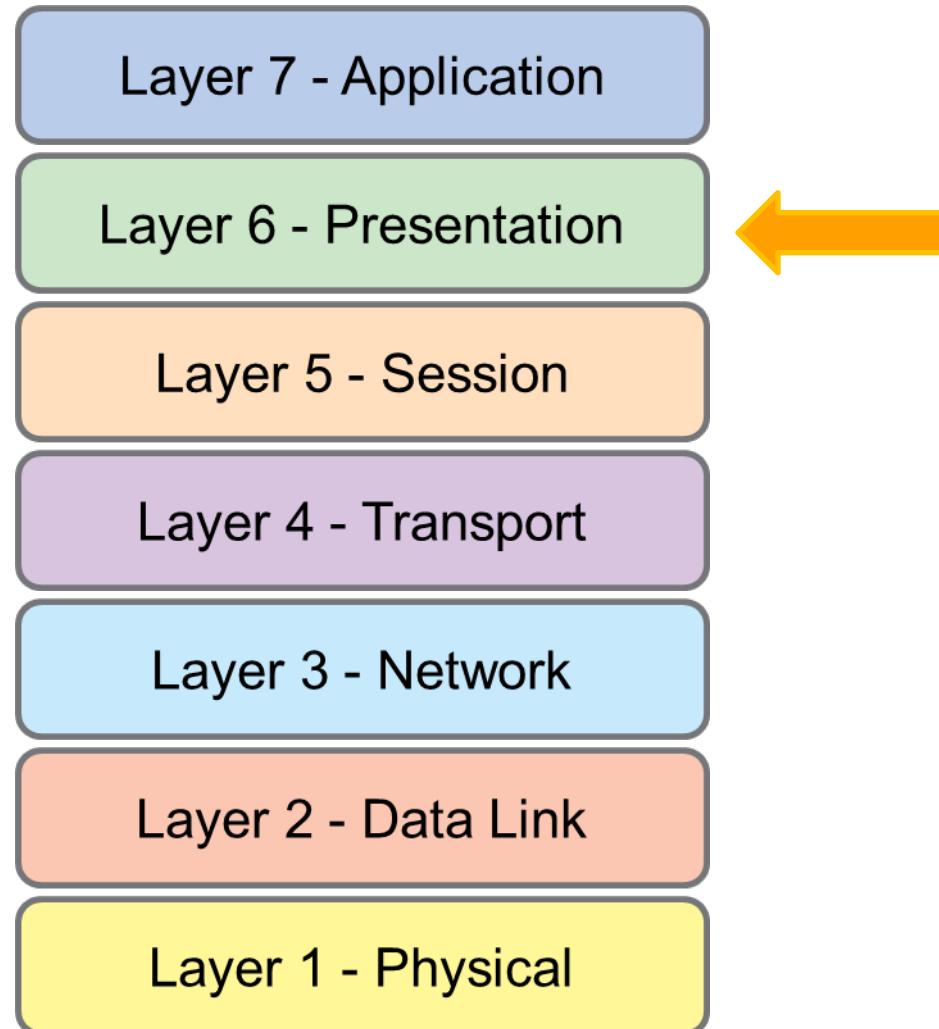
iamkirkbater 5 months ago
Excellent. You have received the joke about
TCP/IP. Goodbye.

Layer 5 – Session



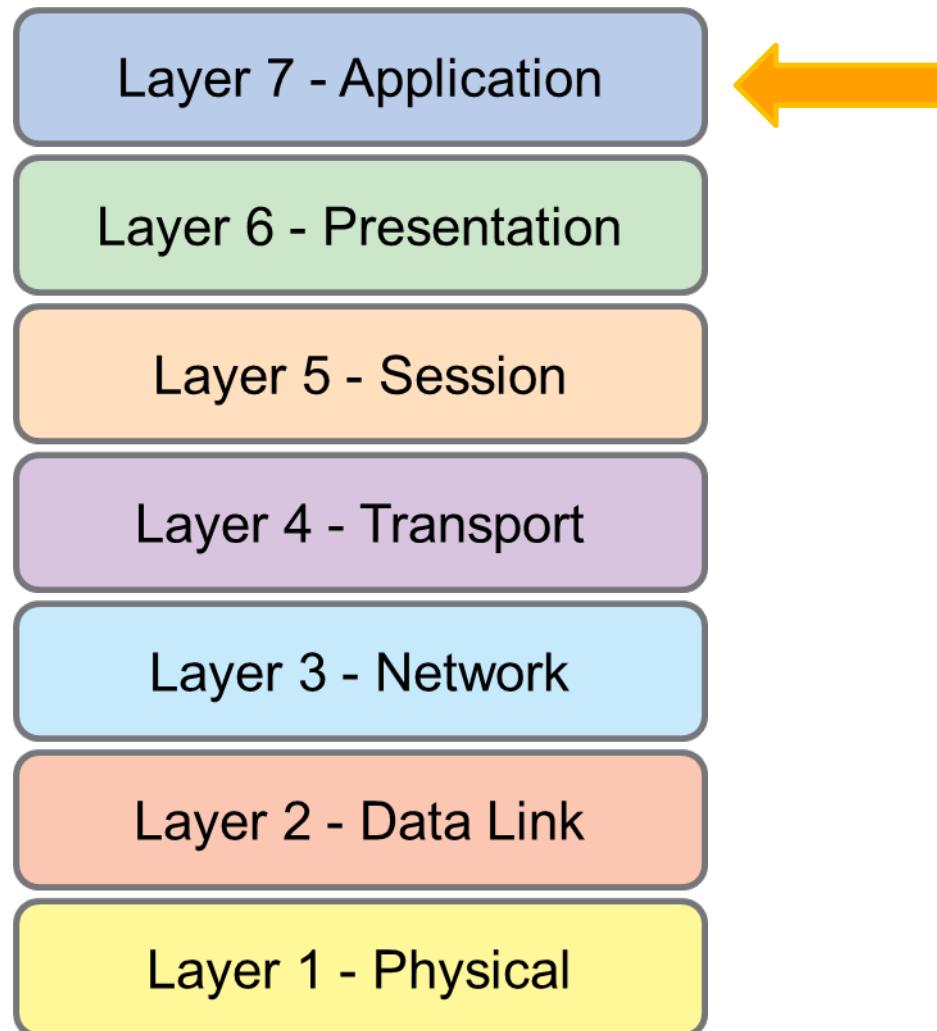
- Opening, closing and managing a session
- Services:
 - Authentication
 - Authorization
 - Session restoration
- Protocols: PPTP, L2TP, NetBIOS, RPC

Layer 6 – Presentation



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

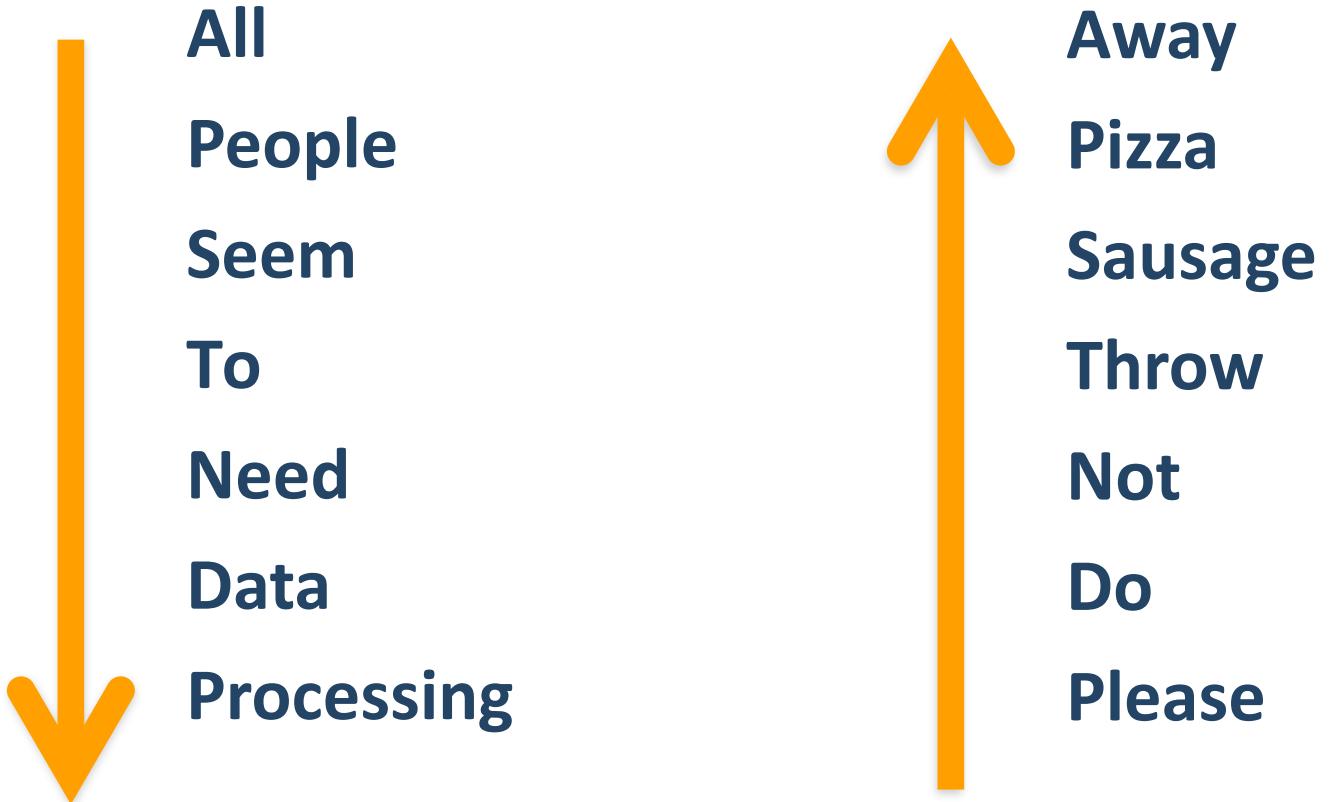
Layer 7 – Application



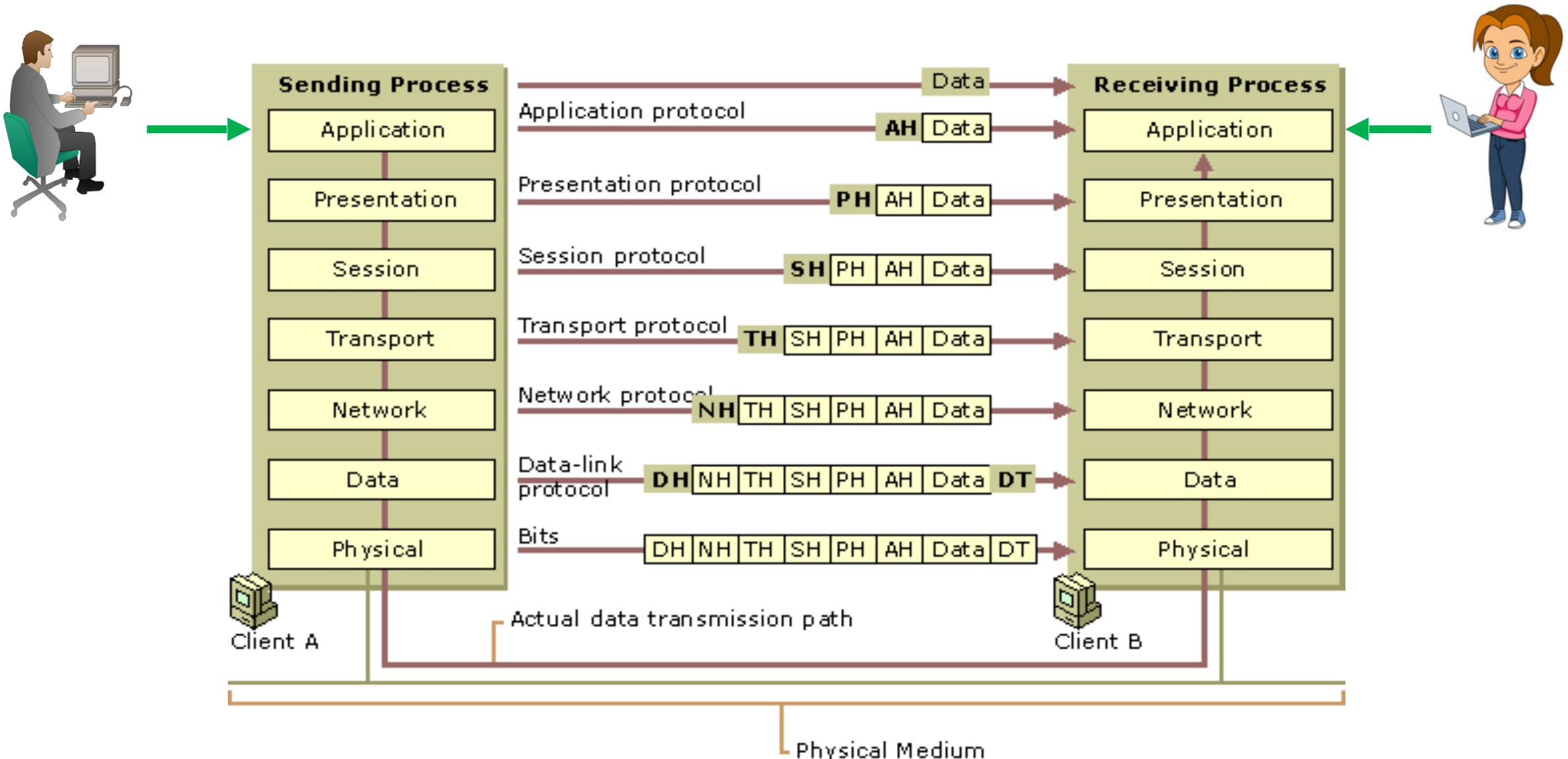
- End-user interaction with the network
- Protocols: HTTP(s), FTP, SMTP, Telnet, SSH, RDP



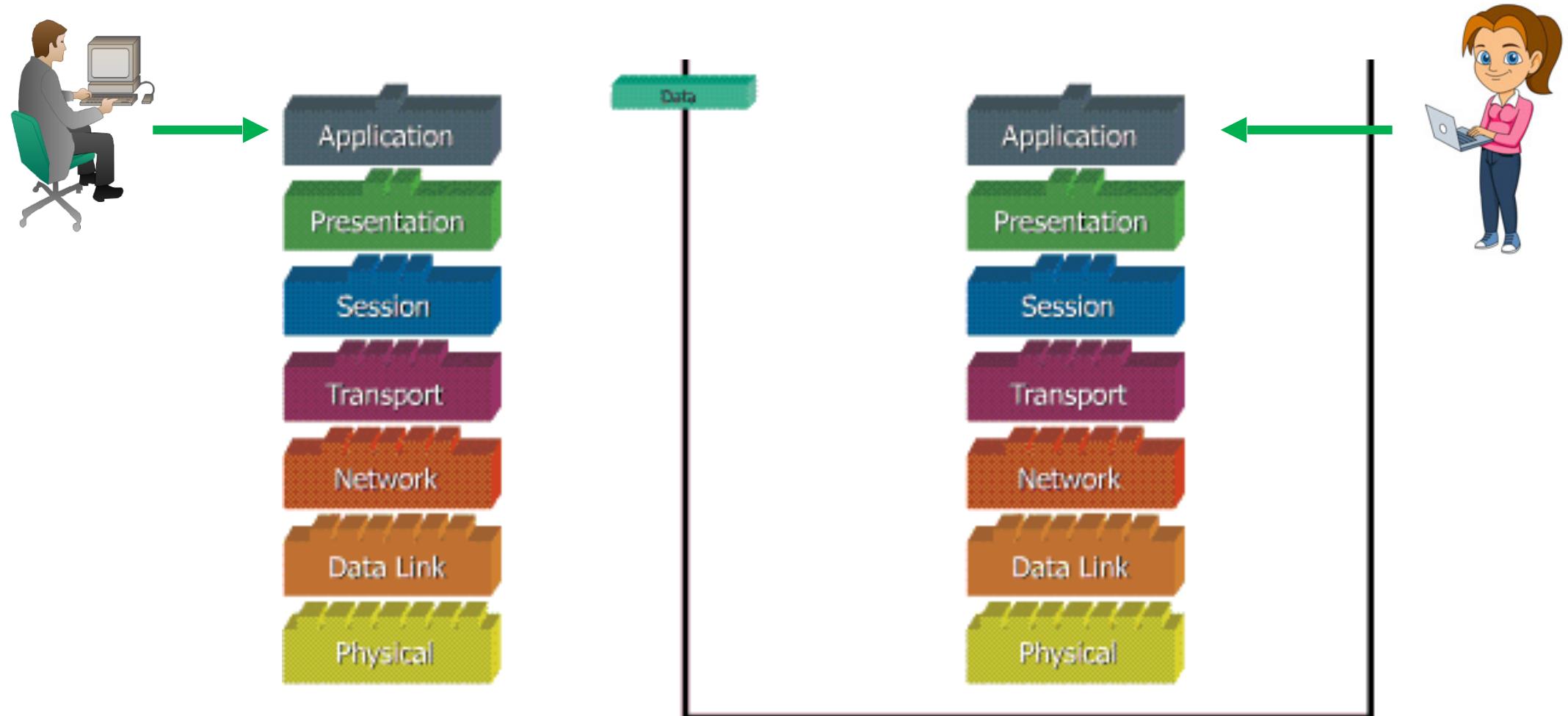
Mnemonics for the OSI Model



Data Flow in the OSI Model



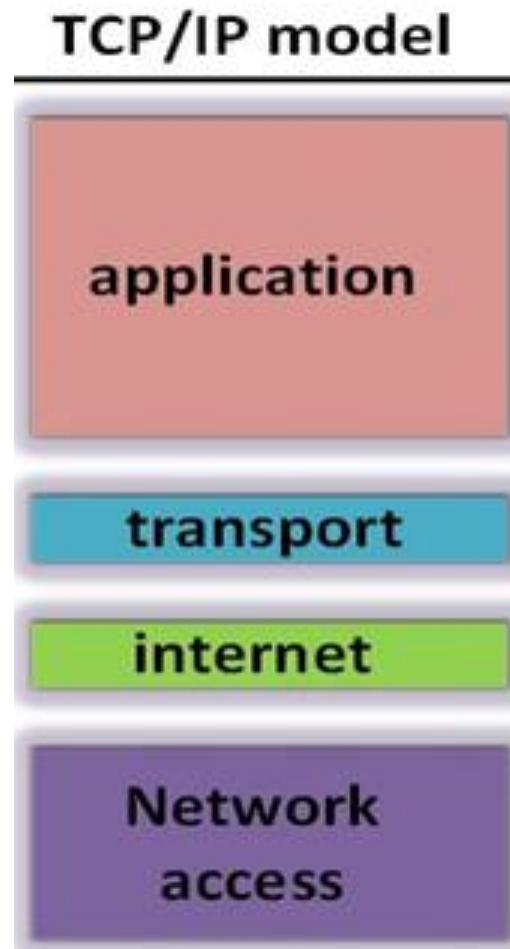
Data Flow in the OSI Model (2)



Encapsulation and decapsulation

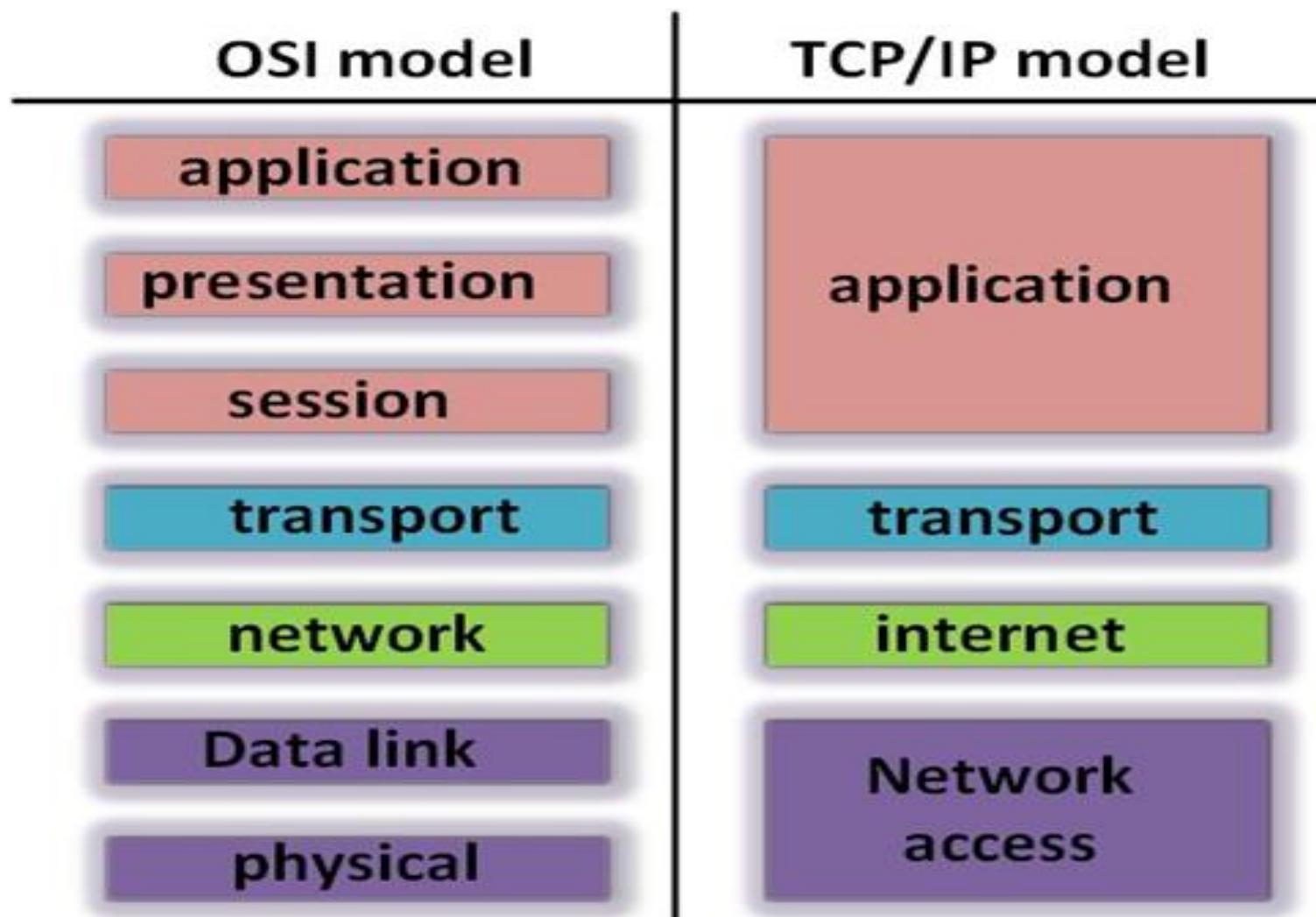
- Encapsulation
 - Each layer adds its own header (and trailer)
 - During the process, the packet goes down through the layers
- Decapsulation
 - Each layer removes the corresponding header (and trailer)
 - During the process, the packet goes up through the layers

The 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

