TCP / IP

- It turns out computers not only have IP but another protocol i.e. TCP as well.

- TCP stands for **Transmission Control Protocol.**

- TCP and IP are commonly used together, you might have heard of term **TCP / IP**.

- TCP lets a **device reliably send a packet** to another device on the same network or on a different network.

- TCP ensures that each packet is delivered if at all possible.

TCP / IP

- **IP mainly supports**
  - Addressing
  - Fragmentation

- **TCP mainly supports**
  - Packets delivery
  - Sequence numbers

- In our example of **McLaren** image , receiver will send request that packet 2 is missing, in return source will send requested packet again!

Revisiting example

- **When we sent this request, how google knows that it's a webpage request? Google has many services like:**
  - Email server
  - Chat server
  - Video Server
  - .

1 . 2 . 3 . 4

5 . 6 . 7 . 8

- Thus, request needs to be more specific.
  - To make clear either it's a request for page
  - Email
  - or video stream

- I would say: **5 . 6 . 7 . 8 : 80**   **80 is port number**

Software / Network Port

- A **software port** is **a virtual endpoint** used in computer networking for communication between devices. It allows computers to distinguish between different types of network traffic, even when multiple services or applications are running on the same device.

Security Concerns

- **Open Ports**: An open port is one that is actively listening for incoming connections. If not properly secured, it can be exploited by attackers.

- **Port Scanning**: A technique used by attackers to find open ports on a device for potential exploitation.

- **Firewalls**: Used to control access to ports by allowing or blocking traffic.

Port numbers

- **TCP standardized port numbers** for different services that server might provide

    - 80   HTTP (Hyper text transfer protocol) is language that webservers speak (message inside envelop)
    - 443   Secure HTTP (HTTPS) or SSL
    - 25   Email / Simple Mail Transfer Protocol (SMTP)
    - 53   DNS
    - 989-990 File transfer protocol (FTP data - Control)
    - .
    - .

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Protocol

- **We discussed**
  - **IP**
  - **DNS**
  - **DHCP**
  - **TCP**
  - **HTTP**
  - **.**

What is Protocol in computer networking?

Protocol in daily life?

Protocol

- **Formally,** A <u>network protocol</u> is an established **set of rules** that determine how data is transmitted between different devices in the same network. Essentially, it allows connected devices to communicate with each other, regardless of any differences in their internal processes, structure or design.

Consider Scenario : **Discussion**

- Let's say you are having a video call / conferencing from your family and connectivity is not optimal for such call and packets are getting missed. Thus, video stream quality is not up to the mark. What we have learned so far, TCP will ensure that every packets delivered to destination. What will happen (in a/m scenario) if TCP keeps intercepting call and sending request for packets resend?

- If video keeps buffering … its annoying (real-time communication)
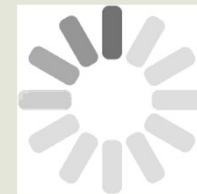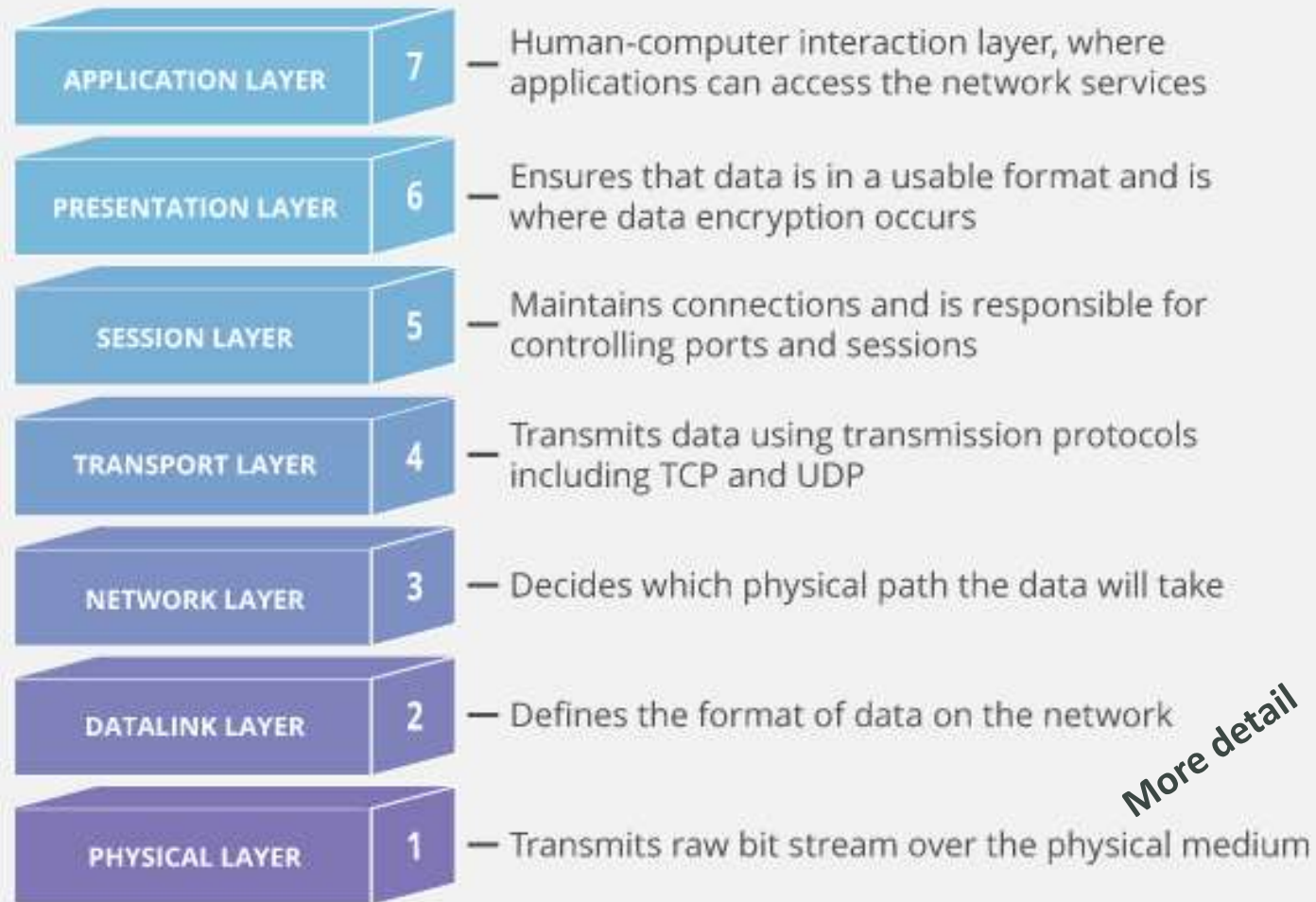
UDP : User Datagram Protocol

- Biggest difference between TCP and UDP is that **UDP DOES NOT guarantee** delivery of packets.

- With UDP, there is no overhead for opening a connection, maintaining a connection, or terminating a connection; data is continuously sent to the recipient, whether or not they receive it

Difference between TCP and UDP

Feature	TCP	UDP
Connection status	Requires an established connection to transmit data	Connectionless protocol

OSI model : 7 layers

- The **Open Systems Interconnection (OSI)** model is a conceptual model created by the International Organization for Standardization (ISO) which enables diverse communication systems to communicate using standard protocols.
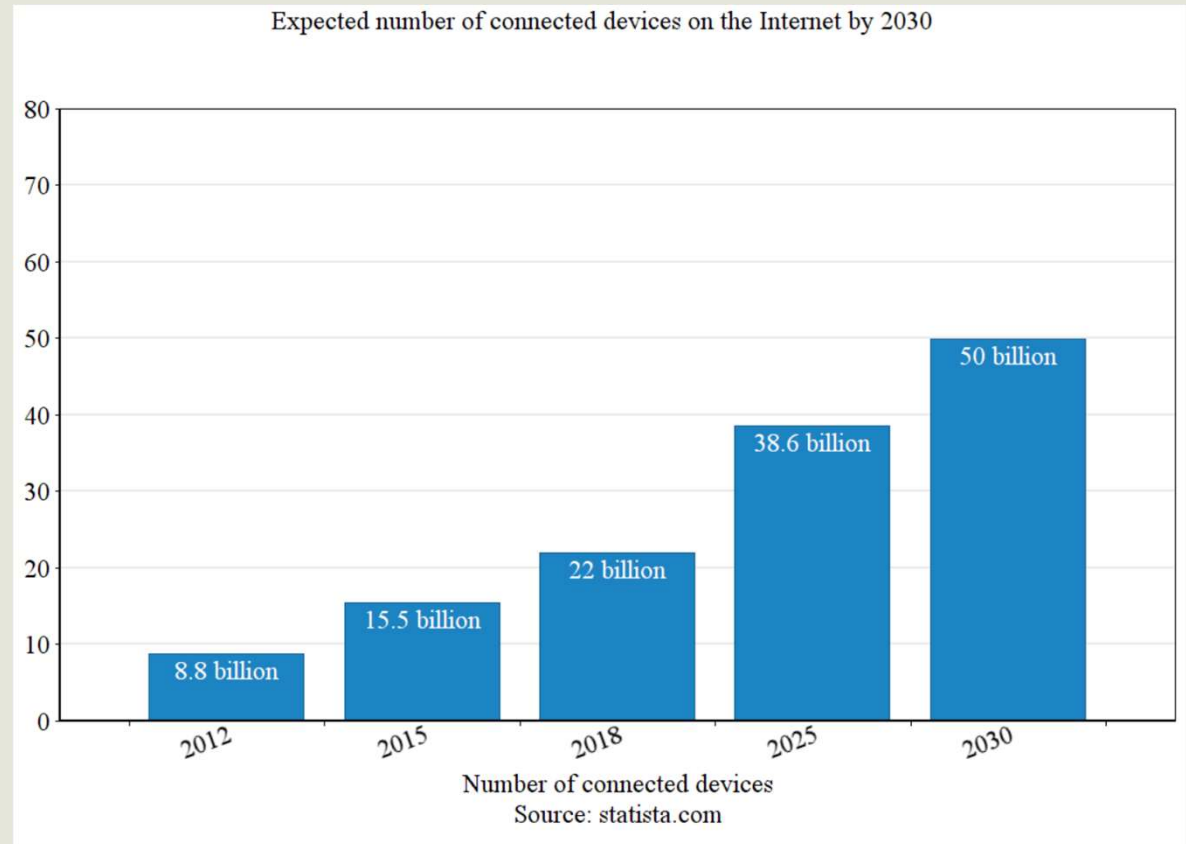
Layer		Description
APPLICATION LAYER	7	Human-computer interaction layer, where applications can access the network services
PRESENTATION LAYER	6	Ensures that data is in a usable format and is where data encryption occurs
SESSION LAYER	5	Maintains connections and is responsible for controlling ports and sessions
TRANSPORT LAYER	4	Transmits data using transmission protocols including TCP and UDP
NETWORK LAYER	3	Decides which physical path the data will take
DATALINK LAYER	2	Defines the format of data on the network
PHYSICAL LAYER	1	Transmits raw bit stream over the physical medium

More detail

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IPs in more details

- We know that, my computer (or any device connected on the internet) has an IP address:

$$\# \ . \ \# \ . \ \# \ . \ \#$$

- Each number has __8__ bits!

- So in total **4 billion** possible IP address (2^{32})

- But now there is a longer version of IP address as well as world is running out of addresses ! (**How?)**
    - **Phones**
    - **Laptops**
    - **Desktops**
    - **IoT device ….**

IPs in more details

■ But now there is a longer version of IP address as well as world is running out of addresses ! (**How?**)

- **Phones**
- **Laptops**
- **Desktops**
- **IoT device ....**

Expected number of connected devices on the Internet by 2030

Number of connected devices
Source: statista.com

IPs in more details

- We know that, my computer (or any device connected on the internet) has an IP address:

$$\# . \# . \# . \#$$

- This is IP version 4 or **IPv4**.

- Instead of using IPv4, gradually world is moving towards **IPv6.**

- IPv6 uses **128 bit** (instead of 32) addresses.

- Total addresses $(\mathbf{2^{128}}) = \mathbf{3.4^{38}}$ **(What to pronounce this)** , will be available to world to use.

IPv4 vs. IPv6

- The main contrast between IPv4 and IPv6 is in the increased number of addresses. **The IPv4 is a 32-bit IP address, and IPv6 is a 128-bit IP address.**

IPv4 **VS** IPv6

IPv4	IPv6
4.2 billion unique IP addresses	3.4 x 1038 unique IP addresses
32-bit address	128-bit address
Numeric	Alphanumeric
Bits divided by a period.	Bits divided by a colon.
Security is dependent on applications	Implements an IP security (IPSec) protocol
Has checksum fields	Does not have checksum fields
Networks are configured manually or with DHCP	Networks are automatically configured

ClouDNS

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IPs in more details

- Verify your network properties

- **There are class of IP addresses that are private:**
  - **10 . ….**
  - **192.168.   ……**
  - **172.16.   ….**

- In this case my laptop is using private IP address, which usually came from local router.

- These addresses are commonly used for local area networks (LANs) in residential, office, and enterprise environments.

Network Connection Details ✕

Network Connection Details:

Property	Value
Connection-specific DN…	
Description	Realtek RTL8723BE 802.11 bgn Wi-Fi A…
Physical Address	3C-A0-67-D1-32-9D
DHCP Enabled	Yes
IPv4 Address	192.168.20.34
IPv4 Subnet Mask	255.255.255.0
Lease Obtained	Monday, June 21, 2021 7:56:58 PM
Lease Expires	Tuesday, June 22, 2021 5:56:48 AM
IPv4 Default Gateway	192.168.20.1
IPv4 DHCP Server	192.168.20.10
IPv4 DNS Server	172.16.10.4
IPv4 WINS Server	
NetBIOS over Tcpip En…	Yes

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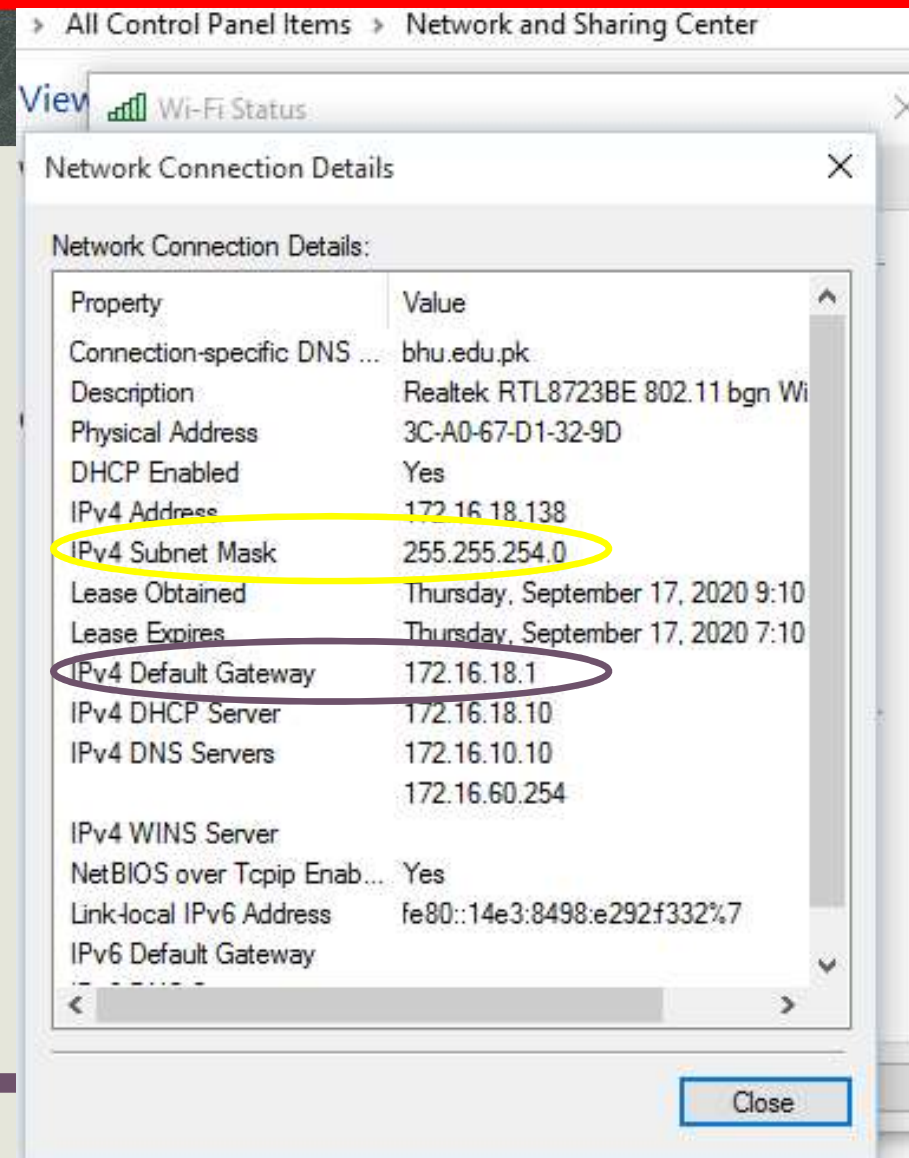(FORMERLY BARRETT HODGSON UNIVERSITY)

IPs in more details

- Private IP addresses means, only with special configuration some other computer can communicate directly to your device.

- **Is this fine?**

- Yes, generally our devices (laptops, phones, xbox) are not servers. Our devices are not providing any services.

- We actually are using different servers for different works:
  - When someone send an email, it doesn't come to our device directly, rather it is stored in a server of email service provider.
  - Take an example or services like FB, Youtube, twitter etc.

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IPs in more details

- **Subnet Mask:** decides whether there can be more devices on the same network

- **Gateway or a router:** is responsible for routing.
  - It is a network node that serves as an access point to another network, often involving not only a change of addressing, but also a different networking technology.

> All Control Panel Items > Network and Sharing Center

View — Wi-Fi Status — ✕

Network Connection Details — ✕

Network Connection Details:

Property	Value
Connection-specific DNS ...	bhu.edu.pk
Description	Realtek RTL8723BE 802.11 bgn Wi
Physical Address	3C-A0-67-D1-32-9D
DHCP Enabled	Yes
IPv4 Address	172.16.18.138
IPv4 Subnet Mask	255.255.254.0
Lease Obtained	Thursday, September 17, 2020 9:10
Lease Expires	Thursday, September 17, 2020 7:10
IPv4 Default Gateway	172.16.18.1
IPv4 DHCP Server	172.16.18.10
IPv4 DNS Servers	172.16.10.10
	172.16.60.254
IPv4 WINS Server	
NetBIOS over Tcpip Enab...	Yes
Link-local IPv6 Address	fe80::14e3:8498:e292:f332%7
IPv6 Default Gateway	

Close

Routers

- How the data is getting routed?
    - How different routes are selected?
    - Satellites , sea routes etc.

- There are lot of devices that are routing data

- **How data is routing? How does it all work?**
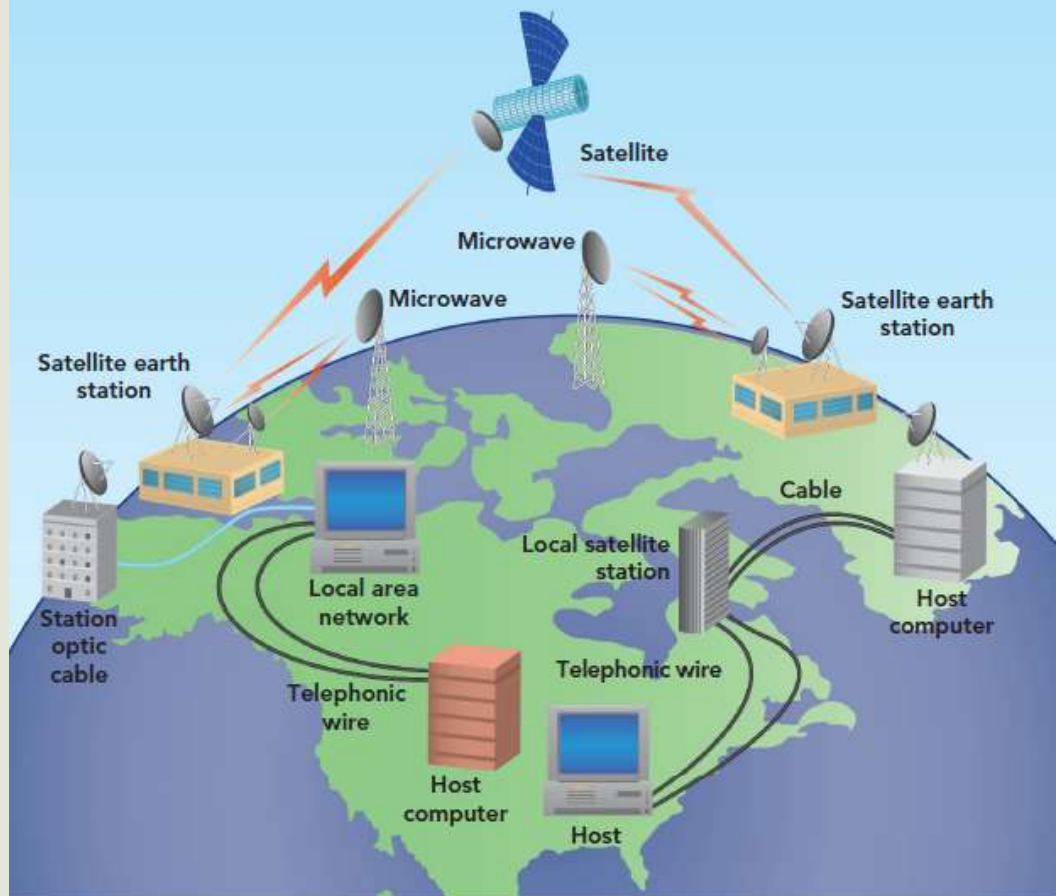
Routers

- Routers are like computers on the internet that have bunches of wires usually coming into and going out of them and they have like a **table in the memory**, where logically they have some prefix of IP addresses and a some explanation where data should be routed to for that specific IP address prefix.

- They route **data to next hop / router**.

Routers

- If router doesn't know next hop?

- No issue, it will send data to another router that probably will have the information where to send / route data.

- Within some number of hops / number of steps data will reach its destination.

- **Usually max. hops = 30!**

Routers

- **Usually max. hops = 30!**

- Software have achieved capability of configuring internet dynamically, so that data can route across
  - Oceans
  - Continents
  - .

- **Multiple ways to route packet to same destination** (design ideology: resilience in network in case of emergency (military application))
  - Fault tolerant
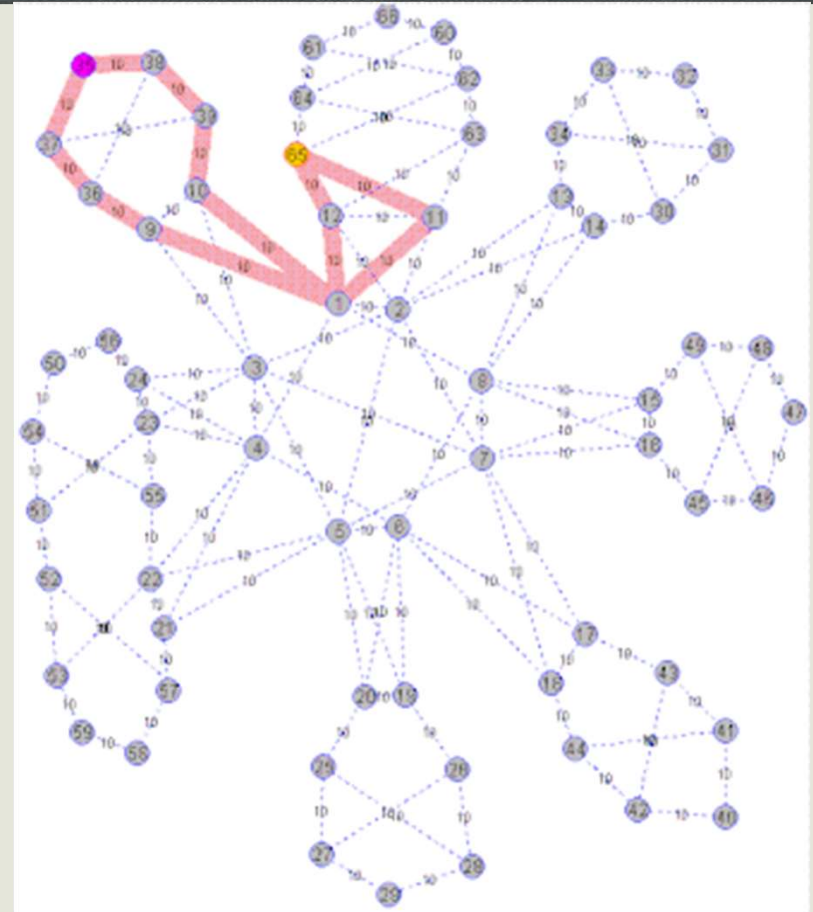
Internet: Network of networks

- **Types of network:**
  - **1 minute – onwards**
  - Distributed networks

  - **2 minutes onwards: design of network**
  - Different operators decide to establish communication b/w networks

Routers : Traceroute

- **Traceroute** : command for
  - displaying possible routes between my computer to another computer, and
  - to measure transit delays of packets across internet.

- Lets trace route between my computer and "google.com"

```
C:\Users\Rizwan.Khan>tracert www.google.com

Tracing route to www.google.com [216.58.207.100]
over a maximum of 30 hops:

  1     1 ms    <1 ms    <1 ms   192.168.20.1
  2    64 ms    97 ms    99 ms   172.16.60.254
  3    45 ms    32 ms    33 ms   124.29.201.169
  4     *        *       53 ms   202.163.100.21
  5    48 ms    45 ms    28 ms   192.168.117.2
  6   139 ms   101 ms     4 ms   192.168.100.21
  7    42 ms    50 ms    34 ms   10.253.4.50
  8    68 ms    67 ms    62 ms   74.125.118.170
  9    60 ms    57 ms    73 ms   172.253.51.205
 10    31 ms    52 ms    39 ms   216.239.62.191
 11    61 ms    69 ms    63 ms   fjr02s04-in-f4.1e100.net [216.58.207.100]
```

Routers : Traceroute

- **Google server t**hat responded to our request was located in **Stockholm Sweden**.

- Reached in 11 hops / steps

IP ADDRESS DETAILS

216.58.207.100

Stockholm, Stockholm, Sweden

◉ Location

City — Stockholm
Region — Stockholm

⌁ Connection

Hostname	fjr02s04-in-f4.1e100.net
Address type	IPv4
ASN	AS15169 Google LLC
Organization	Google LLC (google.com)
Route	216.58.206.0/23
Abuse Contact	network-abuse@google.com
Privacy	VPN ✕ Proxy ✕
	Tor ✕ Hosting ✕

Devices

1. **Cable Modem**
   (modem *modulates* and *demodulates* electrical signals. transforms digital information from your computer into analog signals that can transmit over wires, and it can translate incoming analog signals back into digital data**)**
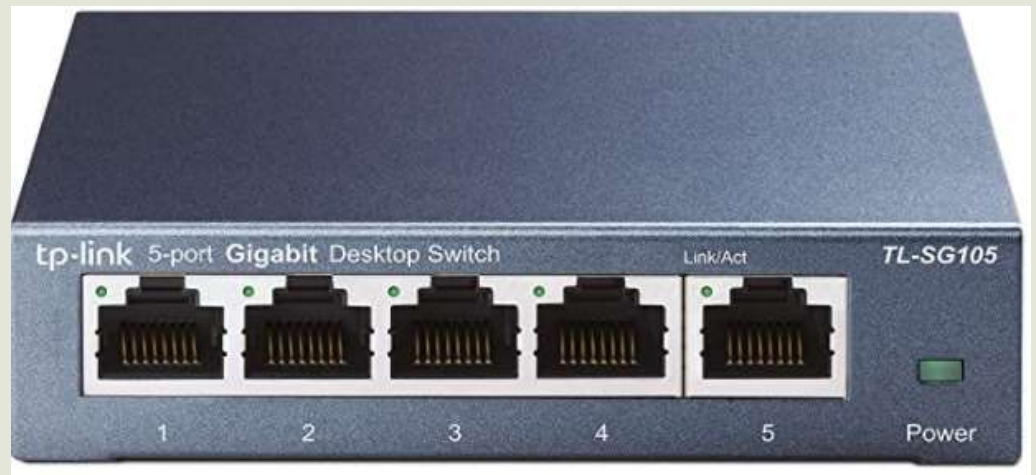
   - Oldest connector (Coaxial)

   - **Telephone Jacks (RJ11)**

   - **Ethernet / LAN connections (RJ45)**

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2. **Switches**

- A network switch also called **switching hub**, **bridging hub**, is networking hardware that connects devices on a computer network to receive and forward data to the destination device.

- Not an intelligent device

Devices

3. **Home router**

- *route* data between devices in your home, and between those devices and the wider Internet**)**
  - **Wifi capability**
  - **Firewall**
  - **Switching capability**

- Sometimes router and modems come as one device

- **Topics:**
  - History
  - Philosophy
  - IPv4
  - IPv6
  - DNS