What actually is the Internet?

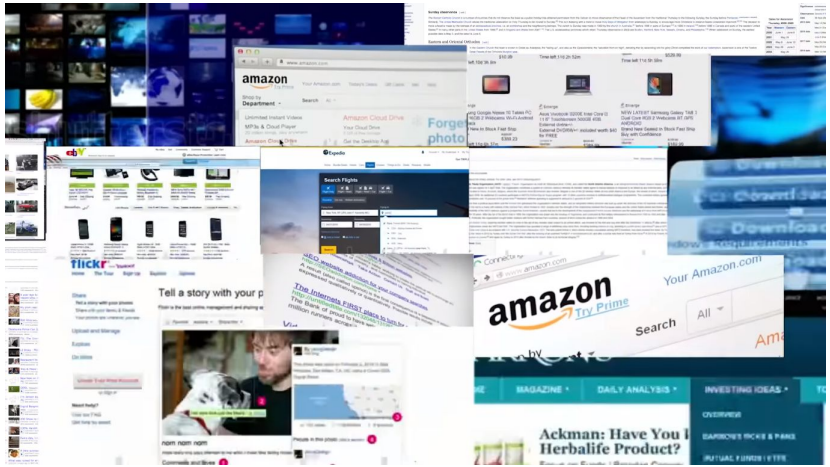
Content

- Introduction
- History of the Internet
- How does the Internet work
- How is data sent through the Internet
- The future of the Internet

Introduction

What is the Internet?

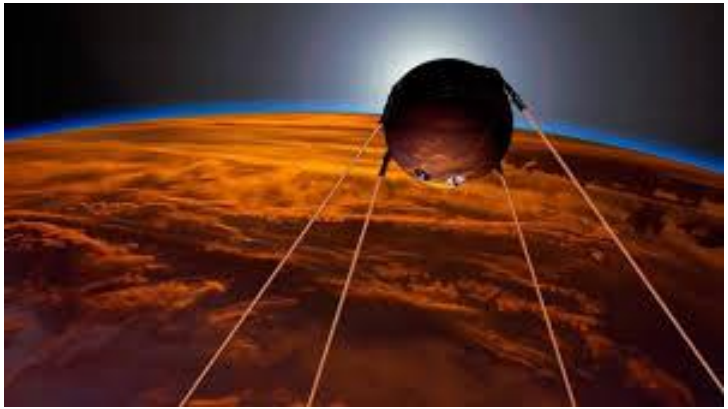
- It is a platform that enables individuals to **access information**, **communicate with others**, and **utilize various online services.**
- It plays a huge role in our day to day life.
- There are **5.35 billion** internet users worldwide, around 66% of the world's population have access to the Internet.
- According to the latest estimates, **402.74 million terabytes** of data are transferred through Internet each day.
- But how did we go from the world with no Internet to this huge numbers.
- Today, we'll find out by exploring exactly how the Internet was made.

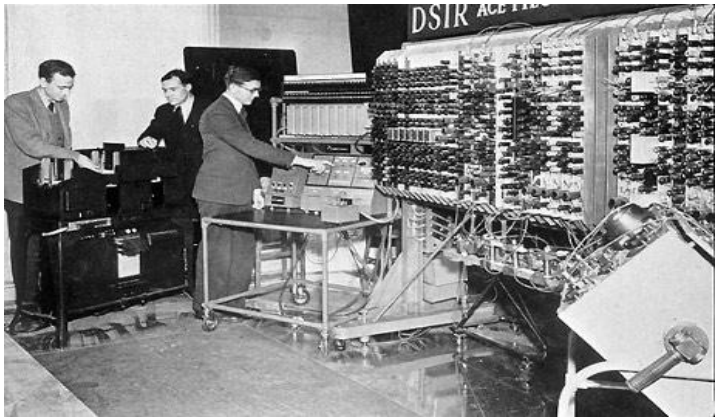


History

History

- The story of the internet begins in the **Cold War** era a time of intense rivalry between the United States and the Soviet Union.
- In 1957 Russia's successful launch of the first manmade orbital satellite called **Sputnik**, highlighting their technological advancements.
- In order to keep their eyes on the Soviets at all times and make sure that the US always had the better technology, the **US Department of Defense** started working day and night.
- But communication b/n research centers were d/t it required to constantly be in contact with one another through phones.
- To facilitate **communication** and **resource sharing** between research institutions, **ARPANET** (Advanced Research Projects Agency Network) was created In late 1960's.
- The U.S. government funded ARPANET to create a robust, **reliable**, and **decentralized** communication system that could be used for **military** and **academic** purposes.





The 1st wide area network

- The very first ARPANET connection occurred on **October 29, 1969** between UCLA and Stanford University.
- The Word "**LOGIN**" was intended to be sent.

L O ⚠ X **System crash**

- But after fixing the problem, they were able to successfully send the complete message

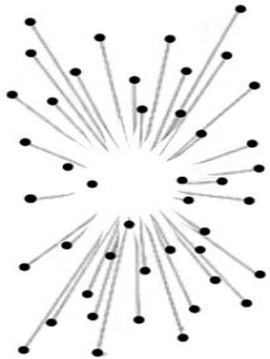
LOGIN **Success**

- This event marked a critical milestone in the development of computer networks and the eventual creation of the Internet.
- The network's speed was 50 kilobits per second (kbps).

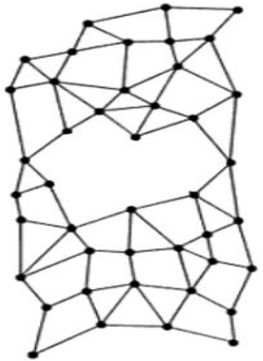
How did they manage the decentralization

- The concept of **packet switching** was developed in the 1960s by researchers **Paul Baran.** he was trying to figure out how to build a communication system that might actually **survive a nuclear attack**
- So he had this idea of breaking messages up into **blocks** and sending them as fast as possible in every possible Direction Through the mesh Network, and then pieces them altogether on the other side.

Centralized

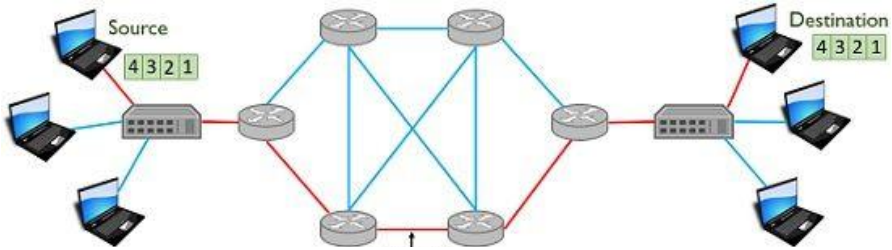


Decentralized



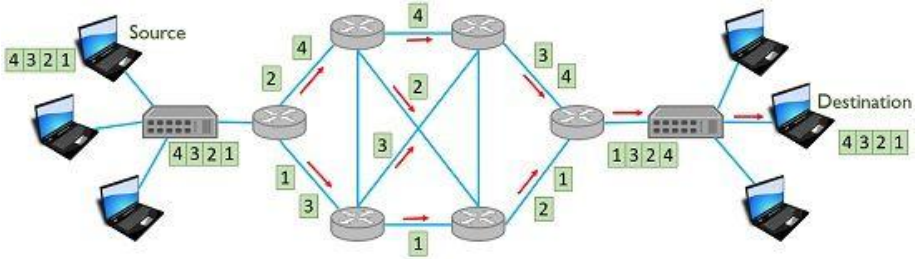
Circuit switching

- Dedicated path is established between the sending and receiving device.
- B/c of path reservation **unused bandwidth on an allocated circuit is wasted.**
- Use simple protocols.



Packet switching

- No dedicated path created between the sending and receiving device.
- Other packets from an unrelated source may utilize unused bandwidth.
- Requires complex protocols



Fun Fact

The Statue of Liberty is a real world example of packet switching

Email

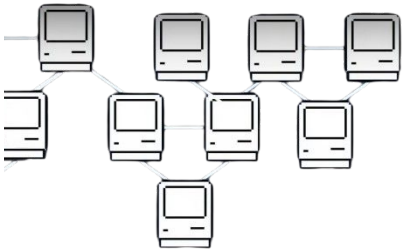
- After these groundbreaking achievements, ARPANET just continued to improve.
- In **1971**, programmer **Ray Tomlinson** developed a messaging program.
- He used the **@ symbol** to separate the user's name from their machine, making addresses easier to read.

  [user]@[computer]

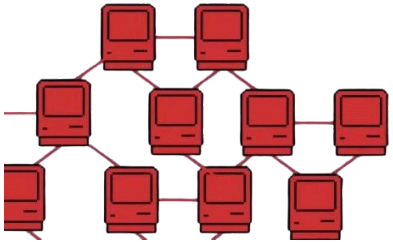
- He called this **Electronic mail** or "**email**"

Inspiration

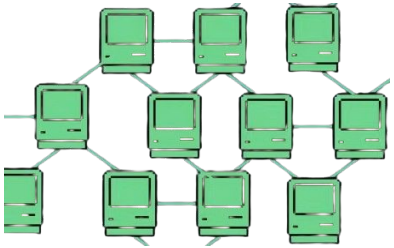
- While it was a complex network of computers, it was more of an "**intranet**," a network that is private and limited to only one company.
- As ARPANET got bigger, so did its influence on other networks
- We've already managed to get computers to connect with each other, but what if we could **interconnect networks**?



ARPANET



NPL

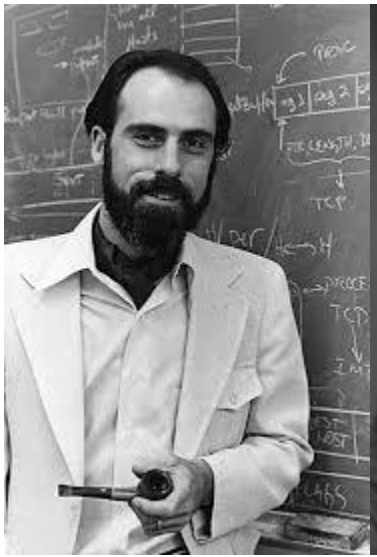


NORSAR

- Interconnecting independent networks wasn't exactly easy b/c each networks had very d/t configurations.
- What if we could create a language that everyone spoke?

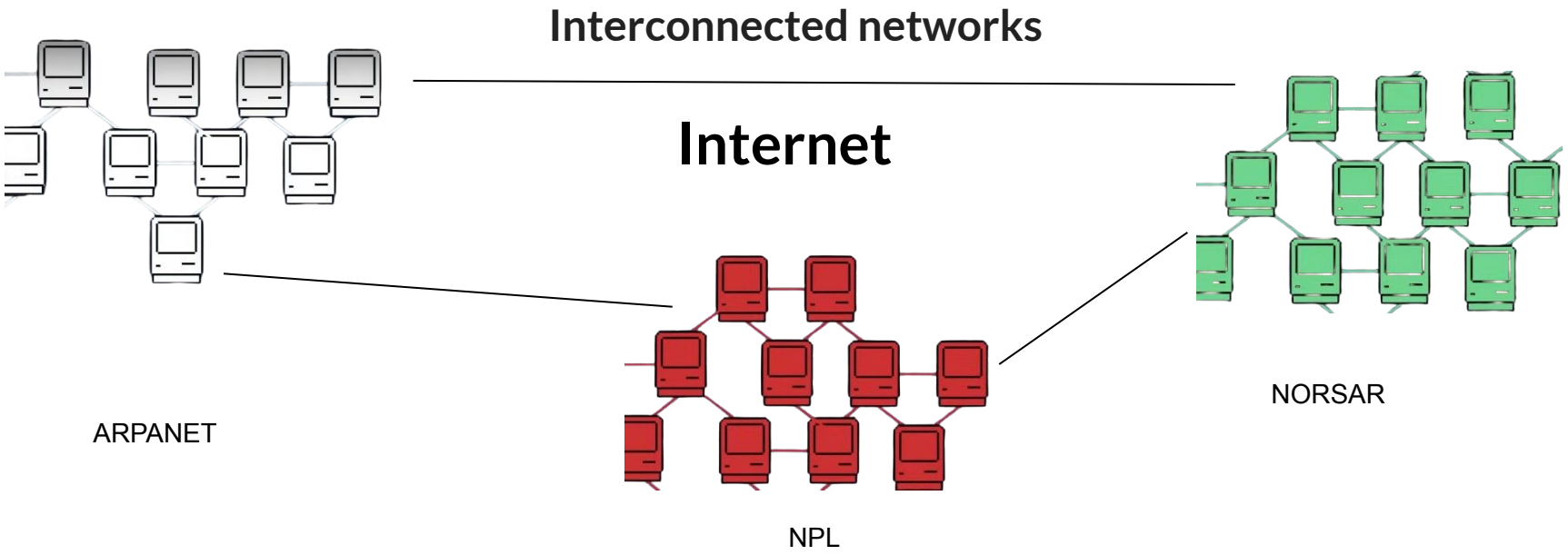
The Birth of the Internet

- In the late 1970's **Vint Cerf** and **Bob Kahn** started working on what we now call the Internet.
- They tried to work on a protocol what now we call TCP/IP
- **protocol:** is a well-known set of rules and standards that if all parties agree to use it will allow them to communicate without trouble.
- These protocols did many incredible things, including
  - ➔ giving each computer its own distinct number, called an IP address,
  - ➔ being able to detect and automatically resend packets that are lost in transmission
  - ➔ being able to confirm that a transmission was successfully delivered.
  - ➔ And most importantly any hardware or software which understands TCP/IP can easy be a part of the Internet.



Internet birth date

- **January 1, 1983,** was basically the day that a bunch of **intranets and extranets** came together to become one big unified internet.

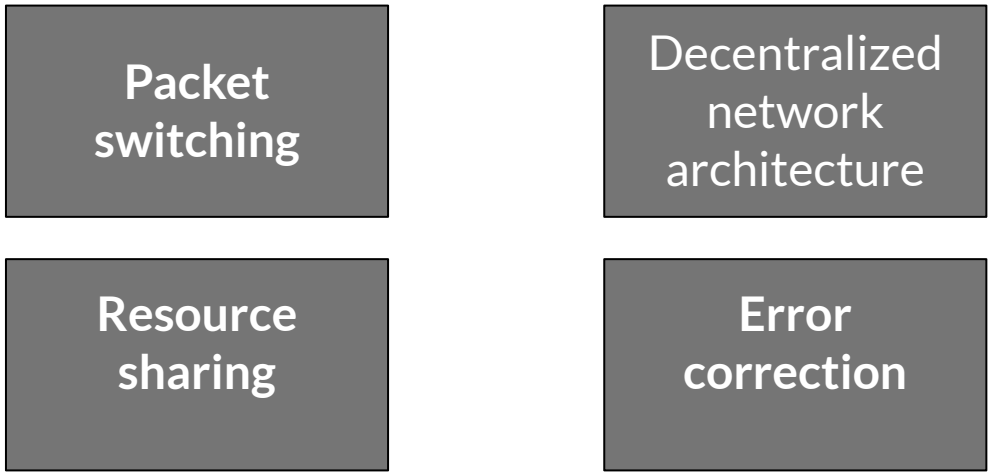


DNS

- ARPANET created a “phone book” listing the name of a server and its numerical address.
- This “phone book” was called “**hosts.txt**” and each computer on the network would automatically have access to it.
- As the internet grew and more domains were registered,Insteadd of a single hosts.txt directory, you now had basically a bunch of hosts.txt directories all on different machines, called **DNS servers**.
- and these would all form their own network, and all the other networks would connect to that network, and any changes to these directories would now be done automatically.

ARPANET

ARPANET was the first operational computer network that became the foundation of the modern internet.



- Over time, more networks around the world would form and become part of the internet.
- The pie was getting bigger, but ARPANET's slice wasn't growing. It was becoming more outdated and less influential, and by 1989, would be decommissioned entirely.
- But the rest of the internet was still there, and only continued to grow,

WWW

- It was now time for the internet to get even simpler
- **Tim Burners Lee**, had an idea: “what if there was a program where, rather than constantly logging in to terminals, , you could share information with just the click of a button?”
- He then turned his NeXT computer into a server which hosted a program he called the **World Wide Web.** Featuring new technologies such as **http** and **html.**
- Data could now be shared in the form of web pages containing hyperlinks, through web browsers such as Nexus.
- The very first website is made public in 1991 to children in public schools and even local libraries.

ISP

- As the audience for the internet grew, companies saw a new market for profit: **Internet Service Providers** were popping up left and right
- They give you a modem, you hook it up to your phone line and computer, and boom, you have internet.
- The role of internet service providers play a vital role in linking users to the Internet by offering various connection methods like DSL cable.
- They assign your device an IP address which serves as its unique identifier on the internet
- ISP's act as intermediaries between your device and The Wider internet

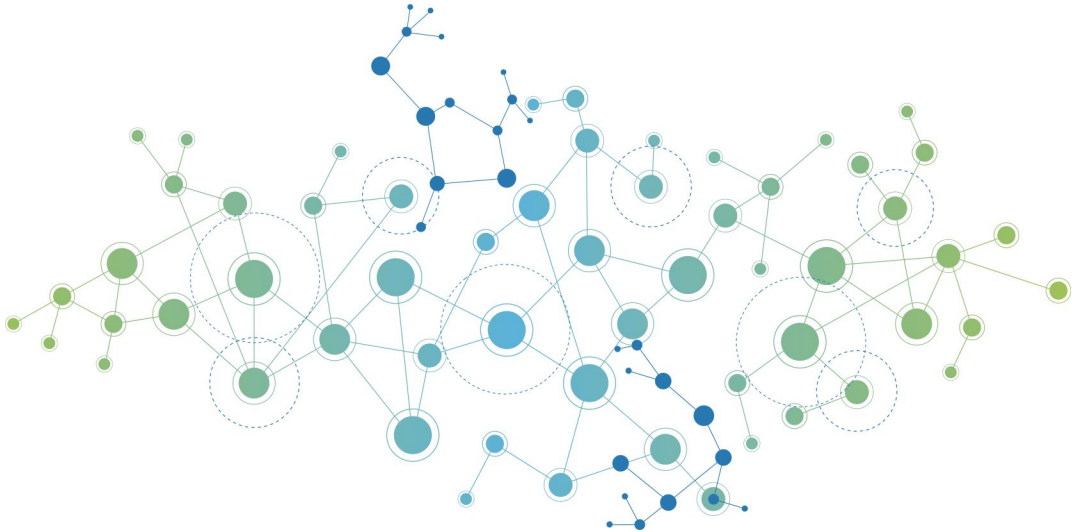
History

- Everyone began contributing their own brilliant ideas to this decentralized structure,
- 1995: Amazon launched
- 1998: Google launched
- 1999: 282 million Internet users
- 2001: Wikipedia launched
- 2004: Facebook launched
- 2005: YouTube launched
- 2006: Twitter launched
- 2009: 1.75 billion Internet users

Modern day Internet

How does the Internet work

- The internet is a **Network of Networks.**
- The Internet is the world's largest computer network.
- There are two main concepts that are fundamental to the way the Internet functions: ***protocols*** *and* **Physical network connections.**



Protocols

Protocols

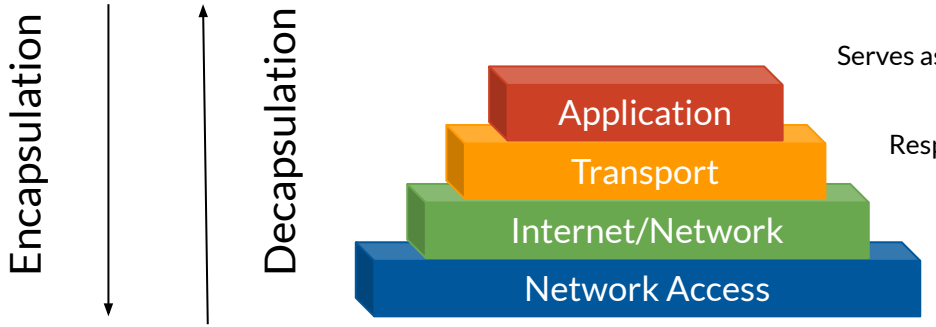
- The Internet is an **open** network: any computing device can join as long as they follow the rules of the game.
- In networking, the rules are known as **protocols** and they define how each device must communicate with each other.
- The Internet protocol suite is therefore often referred to as **TCP/IP**
- Protocol suites are sets of protocols (or rules) designed to work together.

TCP/IP

- It stands for **Transmission Control Protocol/Internet Protocol**.
- Allows computers on the same network to identify and communicate with each other.
- Has two functions
    - **Interoperability**: Works across different hardware and software types.
    - **Standardization**: Provides a common framework for network communication.

TCP/IP Functions

- TCP/IP function through **layering**. By assigning each layer in the stack specific functions to perform on the data
- Ultimately **each layer is completely independent** of all the other layers.
- Each layer has dedicated protocols that they enact on the transmission data.



Serves as the interface between the user application and the network. (HTTP, FTP)

Responsible for end-to-end communication (TCP or UDP)

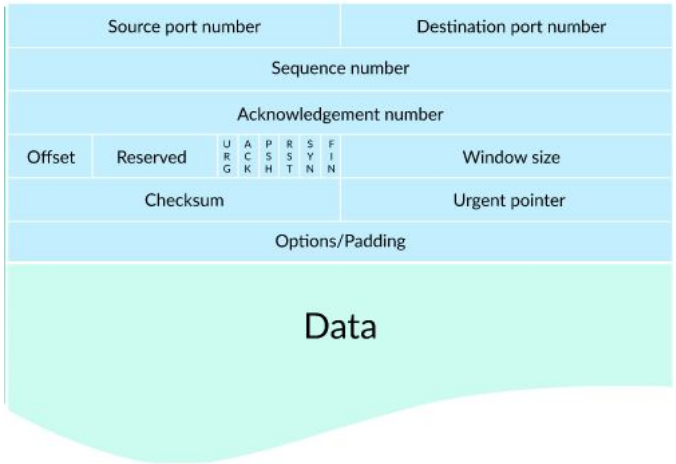
Manages packet routing and addressing (IP)

Manages how data is physically sent through the network (Ethernet, wifi)

TCP/IP Layers

Transport

- TCP includes mechanisms to solve many of the problems that arise from packet-based messaging, such as lost packets, out of order packets, duplicate packets, and corrupted packets.
- In this layer application data is divided it into smaller pieces to form **TCP segment**.

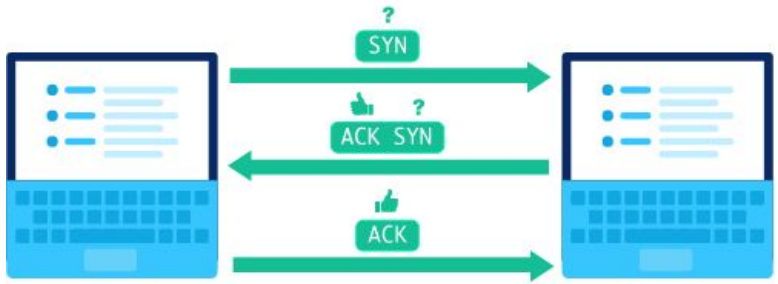


TCP

- The data transmission via TCP has three phases

1. Connection establishment

- connection is set up before data transmission, this will make TCP a connection oriented protocol
- The connection establishment process is called **TCP three-way handshake**



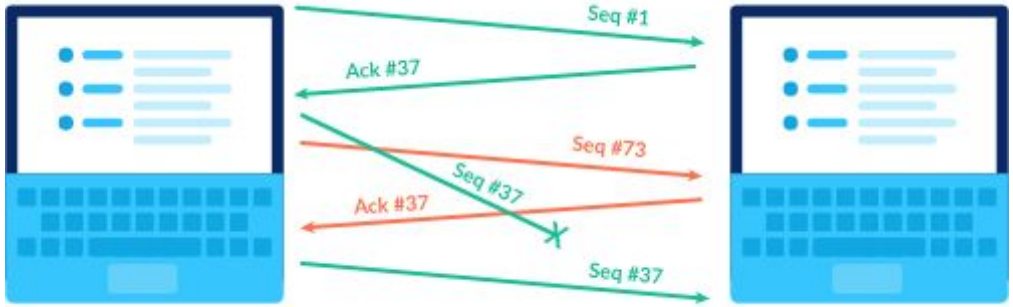
TCP

2. Data transfer

- When a packet of data is sent over TCP, the recipient must always acknowledge what they received.
- **Reliability**: TCP headers facilitate reliable communication by using sequence and acknowledgment numbers to ensure data is received correctly and in order.
- **Detecting lost packets:** does this by using a timeout, After sending off a packet, the sender starts a timer and puts the packet in a retransmission queue. If the timer runs out and the sender has not yet received an ACK from the recipient, it sends the packet again.
- The retransmission may lead to the recipient receiving duplicate packets, if a packet was not actually lost but just very slow to arrive or be acknowledged. If so, the recipient can simply discard duplicate packets.

TCP

- **Handling out of order packets:** TCP connections can detect out of order packets by using the sequence and acknowledgement numbers.
- When the recipient sees a higher sequence number than what they have acknowledged so far, they know that they are missing at least one packet in between.
- The recipient lets the sender know there's something amiss by sending a packet with an acknowledgement number set to the expected sequence number.



TCP

3. Data transmission

- When an endpoint wishes to stop its connection it sends a finished message to the other endpoint
- Follows a **four-way handshake** process

TCP/IP Layers

- When the message reaches the transport layer one of the transport layer protocols that is TCP or UDP is selected

TCP (Transmission Control Protocol)

- **Connection oriented** - Guaranteed delivery
- **Supports segmentation** - if the message is large TCP divides it into smaller pieces and adds a header to form a **TCP segment**
- **Reliable** and guarantees **in order delivery** of data from the sender to the receive
- **Have error checking** - this will make it a bit slow compared to UDP
- 85-90% of the internet traffic is TCP

UDP (User Datagram Protocol)

- **Connectionless** - Best effort delivery
- **Does not support segmentation** - the applications using UDP should send messages short enough to fit into one **UDP datagram**
- **Unreliable** - there is no guarantee that all datagrams sent will be received in the destination and in the correct order
- **Lacks error checking and correction** - it makes UDP fast and efficient for DNS, DHCP like protocols it is also suited for **streaming videos and audios**

TCP/IP Layers

- The transport layer passes TCP segments or UDP datagrams to the network layer
- The network layer adds logical addresses or IP addresses to the TCP segments or UDP datagrams to form an **IP packet** and then uses routers to send the IP packets to other networks

The functions of network layer are

Logical addressing

- Every computer in a network has a unique IP address.
- IP addresses are assigned to ensure that each IP packet can reach the correct destination present in different Networks

IP (Internet Protocol)

- Is one of the core protocols in the layers of the Internet,It's used in all Internet communication to handle both **addressing** and **routing**.
- The protocol describes the use of **IP addresses** to uniquely identify Internet-connected devices.

IPv4 addresses

- The first version ever used on the Internet.
- The format for IPv4 addresses is four sets of numbers separated by dots **74.125.20.113**
- 32 bit format which means it can support round **4.3 billion** unique IP addresses.

IPv6 addresses

- In the 1990s that the IPv4 addresses were running out, the IPv6 protocol was proposed with a much longer addressing scheme. Looks like this: **2001:0db8:0000:0042:0000:8a2e:0370:7334**
- **128 bit** so it can support around **340 undecillion** unique IP addresses.

How are we still using IPV4

- Many existing systems and devices still use IPv4. Upgrading or replacing these can be costly and complex.
- ISPs and organizations need to invest in new hardware and software to support IPv6, which can be a significant financial burden.

Static vs dynamic IP

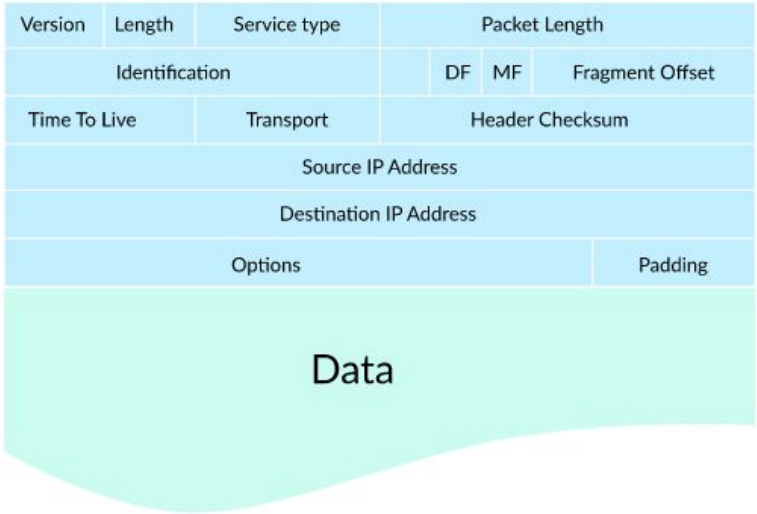
- Your IP address might be different tomorrow than it is today.
- The limited supply of IPv4 addresses led to the introduction of **dynamically assigning IP addresses.**
- Most devices connected to the Internet are assigned temporary IP addresses.
- This is more cost-effective for the ISP than assigning each user a permanent or static IP address.
- Computers that act as servers, like the computers that power Google.com, often have **static IP addresses.** That makes it easier for servers to easily be identified online.

Public vs private IP

- Each device on your network has both a public and private IP address.
- Your ISP assigns your router a **public IP address** so you can go online. This is visible to others on the internet. Public IP addresses can either be dynamic or static.
- The router assigns private ip addresses.
- Your **private IP address** is unique to your device – it's how your router identifies which device on the network has requested what information and knows what data to send you. No-one else can see this private IP address.

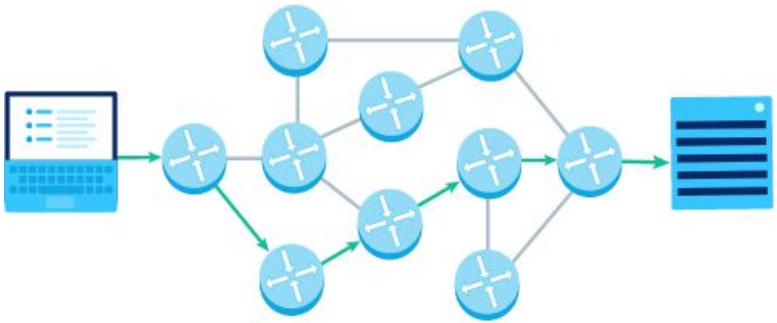
IP packets

- Each IP packet contains both a header and data.
- The header includes the IP addresses of the source and destination, plus other fields that help to route the packet. The data is the actual content.



Internet routing protocol

- The Internet Protocol (IP) is the protocol that describes how to route messages from one computer to another computer on the network.
- What path When there are multiple paths, how does it know which path is best? Once networks become larger, **routing strategies** become more important.

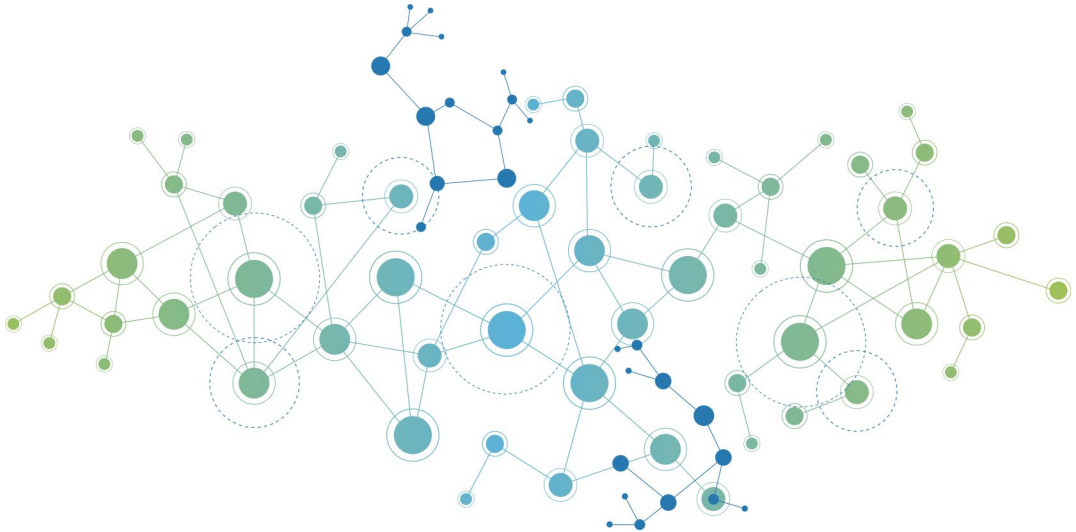


- Computers send the first packet to the nearest **router**(a type of computing device used in computer networks that helps move the packets along).
- When the router receives a packet, it looks at its IP header, which tells the router where the packet wants to end up.
- The router has a **forwarding table** that helps it pick the next path based on the destination IP address.
- Final router forwards message which knows exactly where to send it.

How does the world got connected

Connections

- For most of us, the internet is **virtual**. It's made of Instagram posts and e-mails and YouTube videos.
- But it is A **tangible**, **physical** system that was made to move information.
- And what it's made of and where it goes matters for how we use the internet now.



How does binary data travel

Let's explore how bits are sent and how *quickly* they can be sent

Bit rate: is the number of bits that we can actually send over a given period of time usually measured in seconds.

Bandwidth: is the maximum transmission capacity of a device. bandwidth is measured by bitrate.

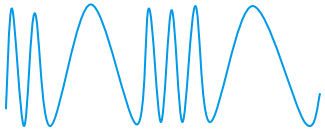
Latency: the amount of time it takes for one bit to travel from the source to the destination device. simply measures how late the bits arrive. measured in milliseconds.

How does binary data travel

- Computers connect to each other and to the Internet via wires, cables, radio waves.
- Bits are physically send by radio waves, electricity and light.

Wireless

Air



- A wireless card inside the computer **turns binary data into radio waves** and transmits them through the **air.**
- Wireless connections are limited in how much area they can cover(**short range**).

How does binary data travel

Copper cables

- That's a CAT5 cable, a type of **twisted pair cable** that's designed for use in computer networks.
- If you were to look inside the cable, you would find four twisted pairs of copper wires
- Twisted pair cables send data through a network by transmitting pulses of electricity that represent binary data:
- With an ethernet wire you see really measurable signal loss over just a few meters.

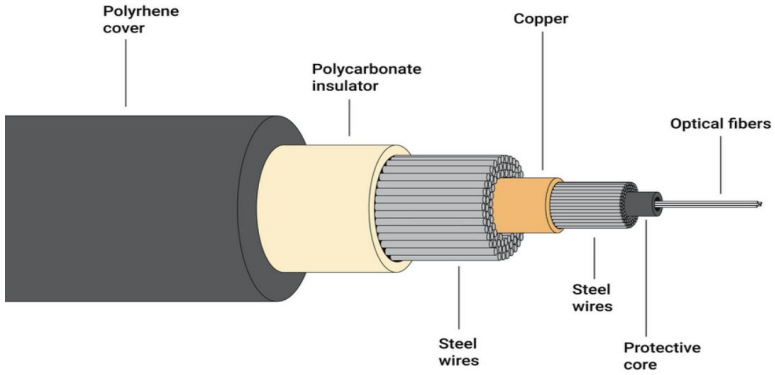
How does binary data travel

Fiber-optic cables

- What else can we use well what do we know that moves a lot faster than just like electricity? **light.**
- We can actually send bits as light beams from one place to another using a fiber optic cable (a thread of glass engineered to reflect light).
- When you send a beam of light down the cable light bounces up and down the length of the cable until it is received on the other end depending on the bounce angle we can actually send multiple bits simultaneously all of them traveling at the speed of light.
- So fiber is really really fast but more importantly the **signal doesn't really degrade** over long distances this is how you can go hundreds of miles without signal loss.
- Fiber-optic cables are capable of transmitting much more data per second than copper cables.

Fiber optic cables

- They're often used to connect networks across oceans so that data can travel quickly around the world
- The fiber is coated with plastic layers and sheathed in a protective tube to protect it from the environment.



Fiber optic cables

How did the world got wired up

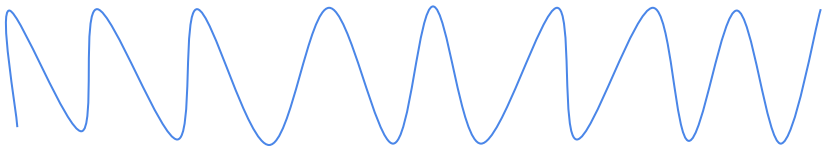
- A big contributor to the fault tolerance of the Internet is the redundancy in network routing paths.
- You can see the world submarine cable map here

The Future of the internet

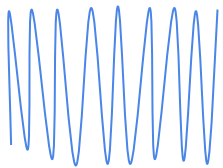
Wireless network technologies

5G

- Why is 5G super fast?
- 5G is built on what's called **millimeter waves** it's a new section of **very high frequency spectrum**



4G



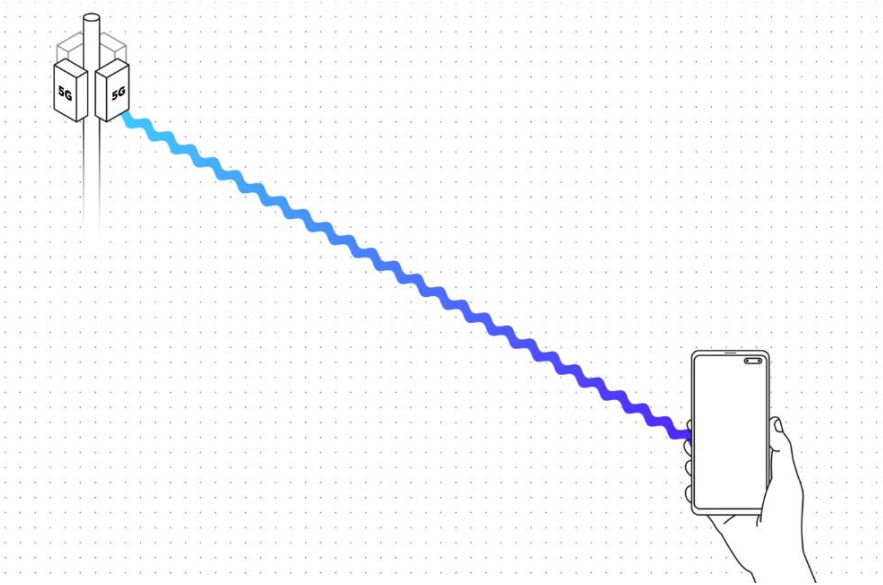
5G

- Because at higher frequencies, you can pack more information into each wave. That is why it is 10x to 100x faster.
- Enhanced bandwidth and reduced latency.
- The **higher the frequency** of any wave **the lesser the range** it covers.

Wireless network technologies

5G

- Also at higher frequencies, it's easier to block those waves.
- Connection is better with direct eye sight.



Future

- **Accelerated IoT device integration**
  Increased speeds will streamline the setup and operation of **smart devices**, making them more user-friendly.

- **Greater support for augmented and virtual reality**
  High bandwidth will enable more sophisticated AR and VR applications, providing richer experiences.

- **Improved telemedicine capabilities**
  Faster connections will enhance remote consultations, allowing for high-quality video and real-time data sharing.

- **Enhanced data analytics and processing**
  Quick data transfer will allow businesses to analyze large datasets more efficiently, leading to better insights.

Thank you

PS: Title inspiration by slow internet at the office!