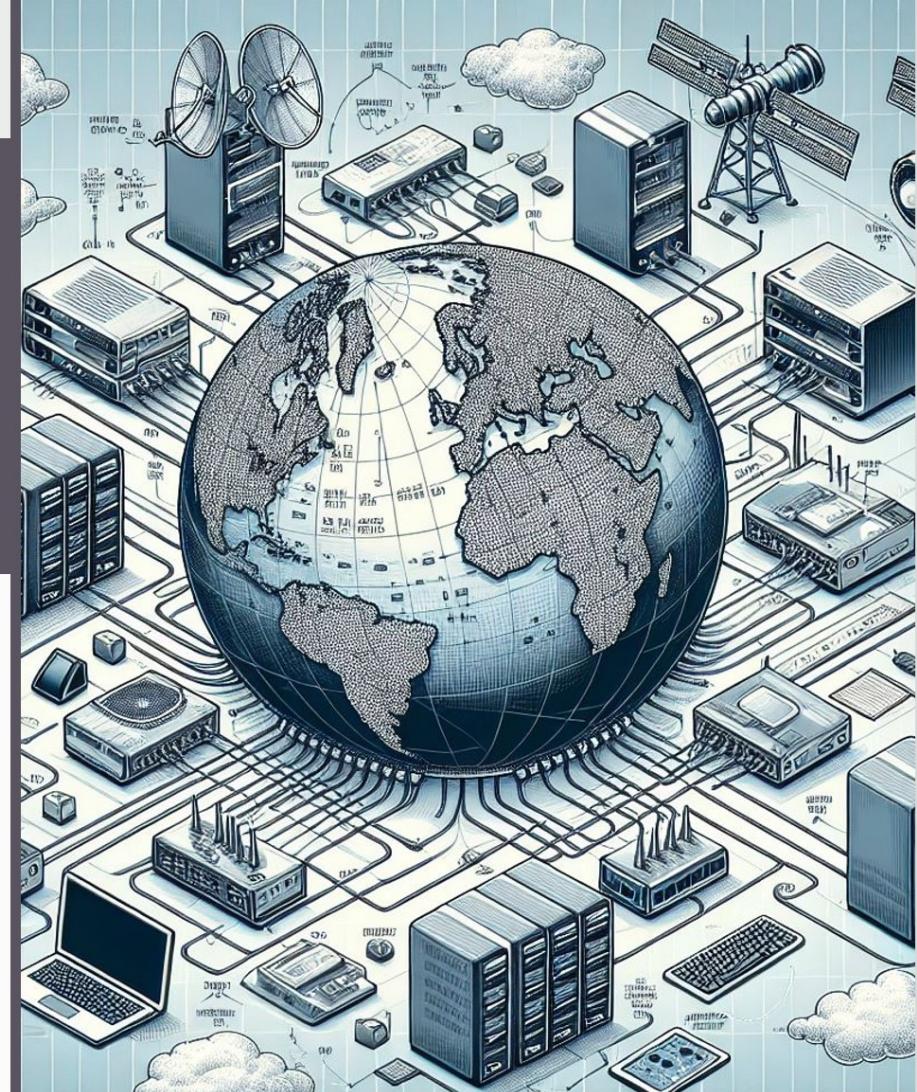


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NETWORKING

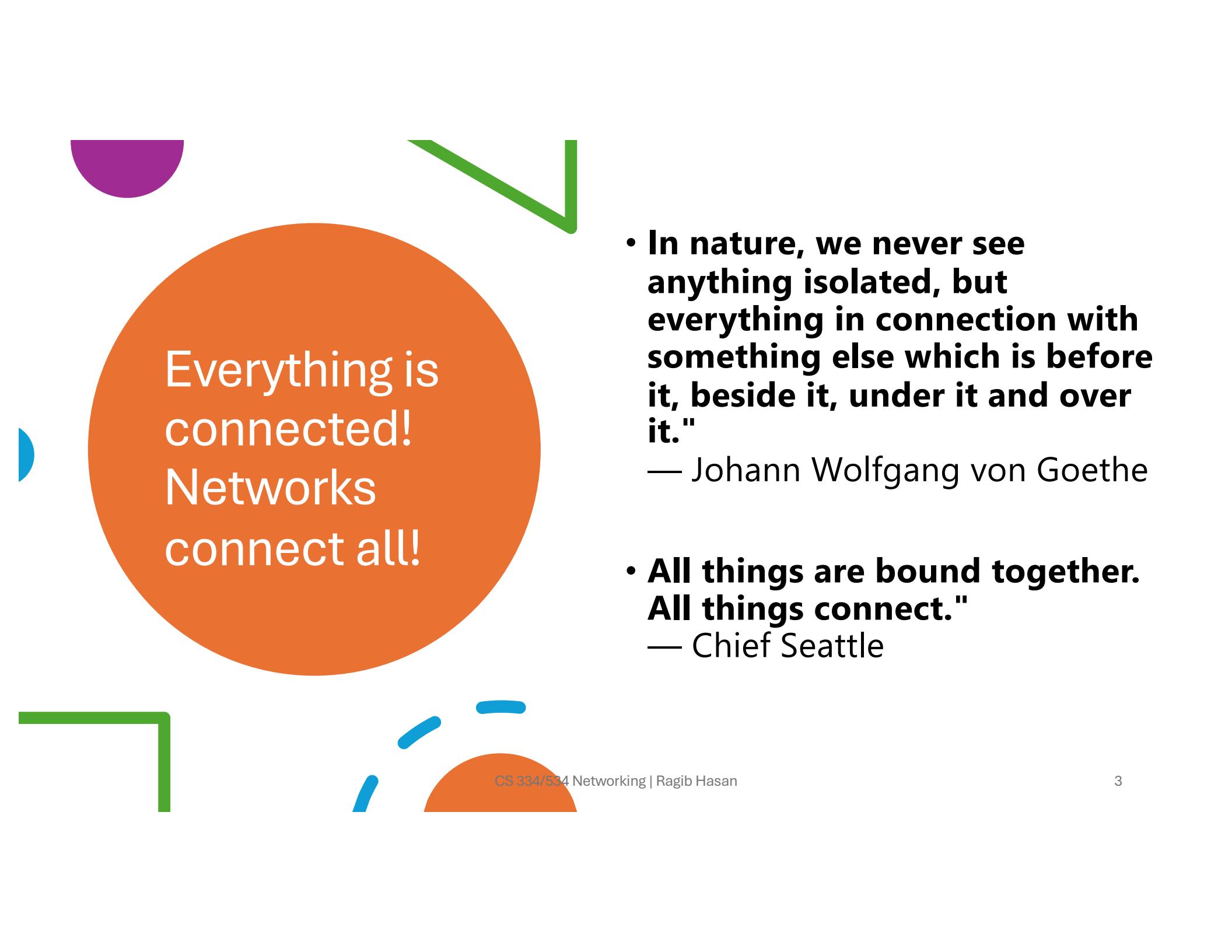
Dr. Ragib Hasan

Lecture 1.1:
Evolution of Networks



Lecture Goals

- Introduce the concept of networks
- Discuss early networks in human history
- Explore the history of electronic communication networks
- Discuss the evolution of the Internet



Everything is
connected!
Networks
connect all!

- **In nature, we never see anything isolated, but everything in connection with something else which is before it, beside it, under it and over it."**
— Johann Wolfgang von Goethe
- **All things are bound together.
All things connect."**
— Chief Seattle

What is a **network**?

- A Network is a collection of nodes or objects, and connections that allow the nodes to communicate with each other
- **What does a network have?**
 - **Interconnected Entities:** The components or nodes in a network are linked together. These nodes can be computers, people, organizations, or any other entities that need to communicate.
 - **Communication:** Networks enable the transfer of data, information, or signals between nodes. This communication can be one-way or two-way.
 - **Resource Sharing:** Networks allow nodes to share resources such as data, hardware, software, and services.
 - **Protocols:** Networks operate based on a set of rules or protocols that govern how data is transmitted and received.



Early Road Networks

- Early road networks were crucial for trade, communication, and military movements.
 - Roman roads: Extensive network connecting the Roman Empire.
 - Silk Road: Trade route connecting Asia and Europe.
 - Inca road system: Advanced network in South America.
- Components:
 - Nodes: Cities
 - Communication lines: Roads
 - Transfer media: Vehicles/horses
 - Protocol: Rules of the road



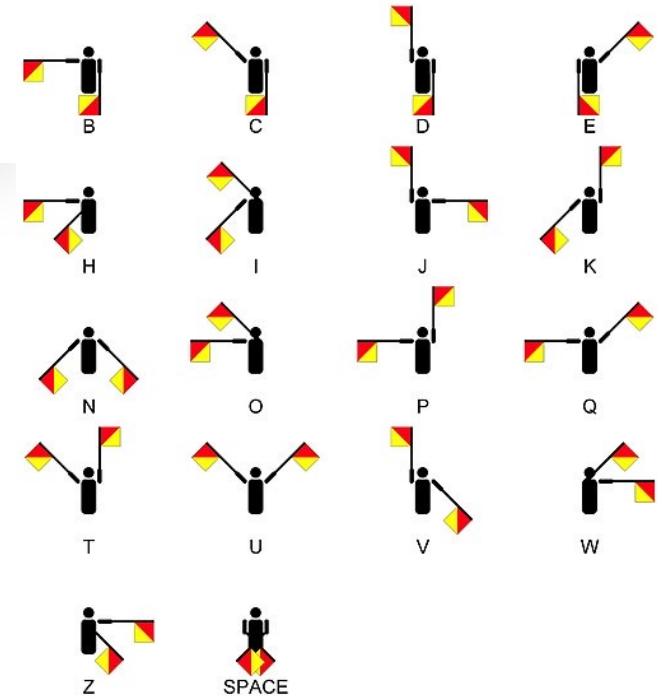
Postal Networks

Postal networks facilitated the exchange of written messages.

- Persian Empire: Established the first postal system.
- Pony Express: Fast mail service in the United States.
- Universal Postal Union: Standardized international mail exchange.
- Components:
 - Nodes: Post offices
 - Communication lines: roads, rivers, sea, air
 - Transfer media: Envelopes/packages
 - Protocol: Postal rules

Early Communication Networks

- Early communication networks enabled long-distance communication.
 - Smoke signals: Used by various cultures for signaling.
 - Beacon chains: Used for relaying messages over long distances.
 - Semaphore lines: Visual signaling systems using towers.



Telegraph Networks (1820s)

Telegraph networks revolutionized long-distance communication.

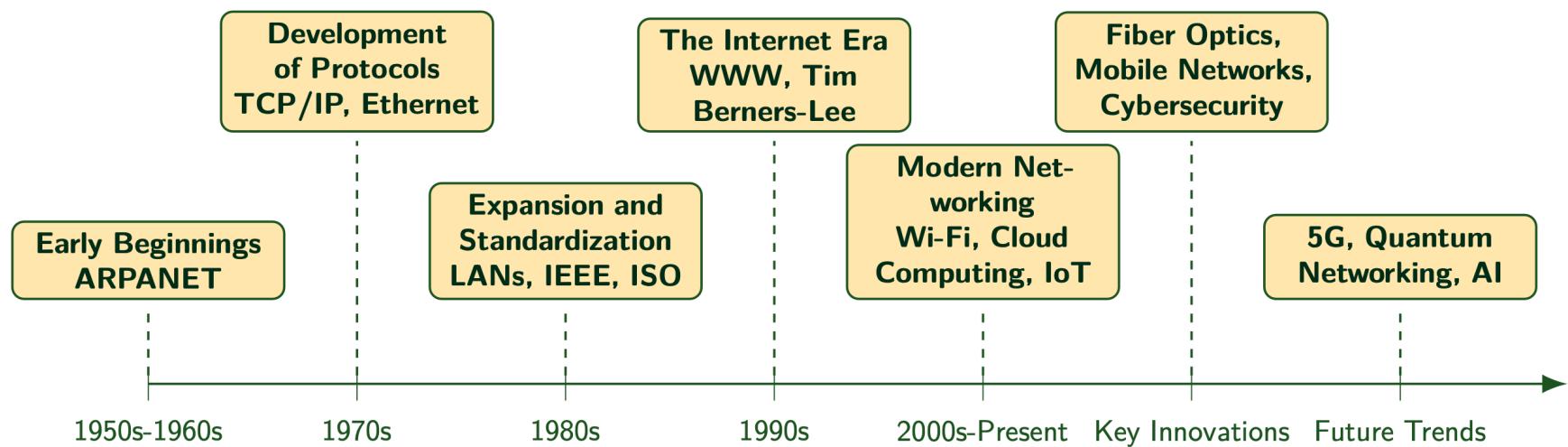
- Samuel Morse: Invented the electric telegraph and Morse code.
- Transcontinental Telegraph: Connected the east and west coasts of the US.
- Submarine Cables: Enabled international telegraph communication.



Telephone Networks (1870s-)

- 
- Telephone networks allowed real-time voice communication.
 - Alexander Graham Bell: Invented the telephone.
 - Bell Telephone Company: Established the first commercial telephone service.
 - Automated Switching: Enabled direct dialing without operators.

Modern communication networks



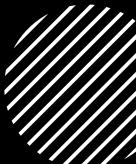
SAGE (Semi-Automatic Ground Environment)

- During the cold war, IBM-built SAGE (Semi-Automatic Ground Environment) for the US Military to detect Russian nuclear bombers.
- SAGE was an early computer-based air defense system, which integrated radar data and provided real-time tracking of aircraft.
- Pioneered the use of computers for networked communication.





Cold war worries creates new innovations in networking



Earlier communication networks were based on telephone and radio signal lines



A major worry was what would happen if key communication lines were destroyed during an enemy attack



Out of this fear, researchers wanted to build efficient yet redundant, failure tolerant, robust networks



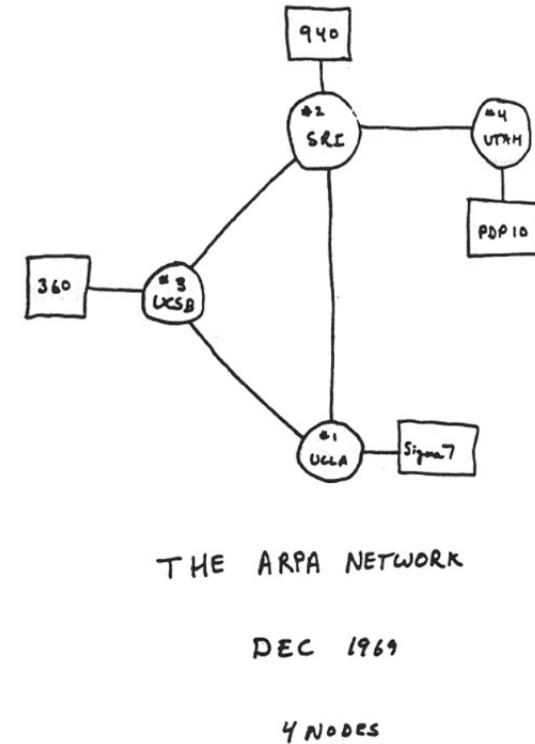
And out of all these, modern networks were born

How can a network survive in the face of disaster?

- Dedicated communication lines are also vulnerabilities – if it is taken down, communication is impossible
- What if, there were multiple communication pathways between two points, and messages didn't have to follow a specific path all the time?
 - In that case, failure of a part of the network will still allow communication to go on
- Out of this hunch, Packet Switching and modern networking were born! (1960s)

ARPA (1969)

- The United States Advanced Research Projects Agency (ARPA) Network was the network that provided the foundations of the internet.
- A number of the network protocols in use today were first developed for ARPANET.
- First used in 1969, it became the first public packet-switched computer network, with its major purposes revolving around academia and research.
- Introduced packet switching and TCP/IP protocols.
- First four nodes: UCLA, UCSB, Stanford Research Institute, Utah
- **First message sent in 1969 between UCLA and Stanford.**



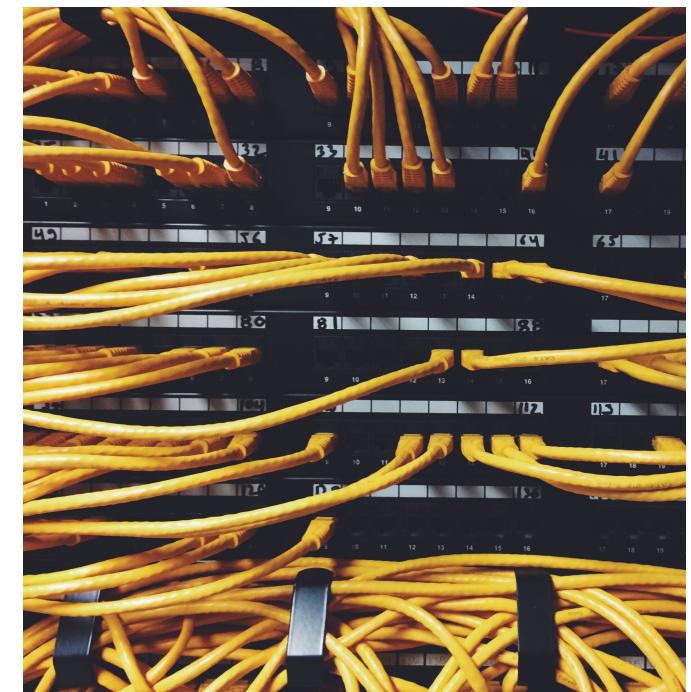
The first ARPAnet message: lo

29 OCT 69	2100	LOADED	OP. PROGRAM	CSK
		FOR BEN BARKER		
		BBN		
22:30		Talked to SRI	CSIC	
		Host to Host		
		Left op. program	CSIC	
		running after sending		
		a host dead message		
		to imp.		

- **When?:** On October 29, 1969 at 10:30 PM PST
- **Who sent it?:** UCLA student programmer Charley Kline
- Where it was sent from: UCLA's SDS Sigma 7 Host computer
- Where it was sent to: Stanford Research Institute's SDS 940 Host computer
- What was intended: The intended message was "login"
- Why it was "lo": The system crashed after Kline typed the first two letters
- How it was received: Kline and SRI programmer Bill Duvall used telephone headsets to communicate while the message was being transmitted

ARPAnet grew among academia and labs

- ARPANET saw rapid growth in the 1970s, as it proved attractive to many universities and government computers.
- The network was declared operational in 1975 and was used to further communications technology.
- At this point, satellite links enabled computers from other countries to be added to ARPANET.
- Additionally, the first email was sent over ARPANET in 1971.
- A new problem – if everyone is connecting their own networks to ARPAnet, they must speak the same “language”. That is, there was a need for standardized protocols and data exchange methods.
- TCP/IP was developed on ARPANET to enable communication between different networks. It first came into operation in 1977. By enabling the interconnection of different networks, TCP/IP cemented itself as the foundational technology of the internet.



Other technologies fueled the need for networks

- Early computers were large mainframes – located in big corporations or government agencies
- 1960s and 70s brought forth minicomputers and microcomputers
- Soon, people were working on their own computers/workstations, but needed to communicate
- Key tech: Unix, PDP and other minicomputers, Standard Encoding (e.g. ASCII, EBCDIC), Fiber optic lines, modems, Ethernet



Rise of Ethernet and networked computers

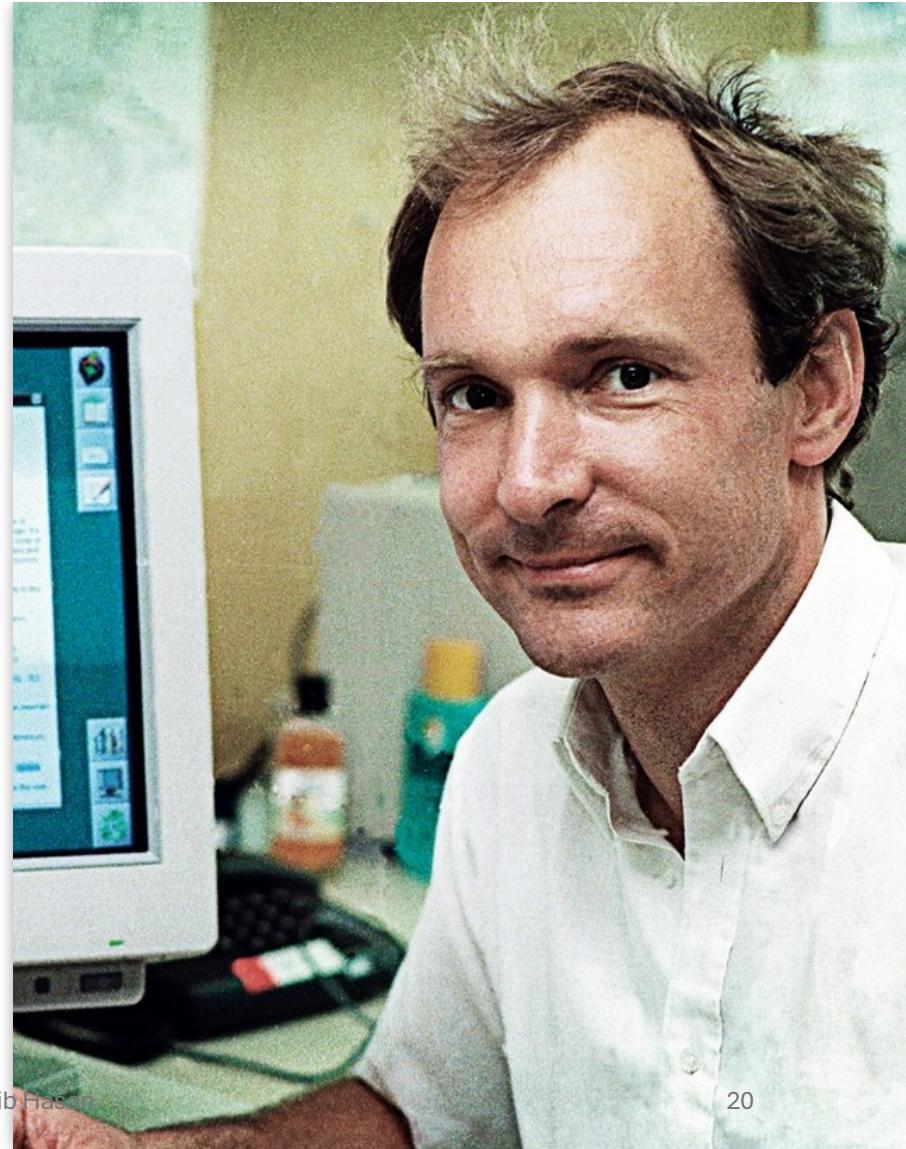
- Through Xerox's famed Palo Alto Research Center (PARC), Ethernet was developed in 1973.
- The Xerox networking system originally operated at 2.94 Mbps. However, it was experimental thus it was not implemented for commercial use.
- In 1979 the DIX consortium, constituting Digital Equipment Corporation, Intel, and Xerox, was formed. It put in place the specification for standard 10Mbps Ethernet that was published in 1980.

NSF Net – precursor to the Internet

- The National Science Foundation set up a network (NSFNet) to connect academic institutions in 1986.
- It was limited to non-profit academic research.
- The Internet truly became public in the early 1990s.
- The internet is a global network connecting millions of devices.
- Early applications on the Internet include Usenet, Emails, Gopher, FTP, etc.
- The thing we generally call “Internet” is actually one specific application of the Internet, namely the World Wide Web
- The **World Wide Web** is NOT equal to the **Internet!!**

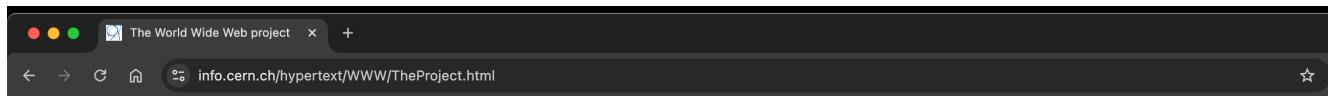
World Wide Web (WWW) is an application of the Internet

- British scientist Tim Berners-Lee created the World Wide Web in 1989, while working at the CERN.
- The original goal was to create a hypertext system, where pages are linked to each other by clickable hyperlinks.
- Among multiple competitors, WWW / http became the dominant user application protocol



The First Webpage

- <https://info.cern.ch/hypertext/WWW/TheProject.html>



World Wide Web

The WorldWideWeb (W3) is a wide-area [hypermedia](#) information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an [executive summary](#) of the project, [Mailing lists](#), [Policy](#), November's [W3 news](#), [Frequently Asked Questions](#).

[What's out there?](#)

Pointers to the world's online information, [subjects](#), [W3 servers](#), etc.

[Help](#)

on the browser you are using

[Software Products](#)

A list of W3 project components and their current state. (e.g. [Line Mode](#), [X11 Viola](#), [NeXTStep](#), [Servers](#), [Tools](#), [Mail robot](#), [Library](#))

[Technical](#)

Details of protocols, formats, program internals etc

[Bibliography](#)

Paper documentation on W3 and references.

[People](#)

A list of some people involved in the project.

[History](#)

A summary of the history of the project.

[How can I help ?](#)

If you would like to support the web..

[Getting code](#)

Getting the code by [anonymous FTP](#), etc.

Wireless networking

- The Wi-Fi standard was released (802.11) in 1997 with 2Mbps speed.
- 1997 saw the introduction of the first 802.11 Wi-Fi standard. It provided speeds of up to 2Mbps. It was made official in 1999, with the capability to reach transmission speeds of 25Mbps and used the 5GHz frequency band.
- More recent standards can use gigabit speeds using Wifi.
- Mobile companies also introduced faster mobile data networks, with latest protocols such as 5g transmitting in gigabit per second rates.

Key points to remember

- The beauty of the Internet is its simplicity
- The clean split of functionality across multiple layers allowed innovation
 - As an analogy, in roads, the same company doesn't build roads and buses and sell bus tickets. Similarly, the Internet is essentially a very efficient road, on top of which people can write different applications (e.g., web browsing, VoIP)