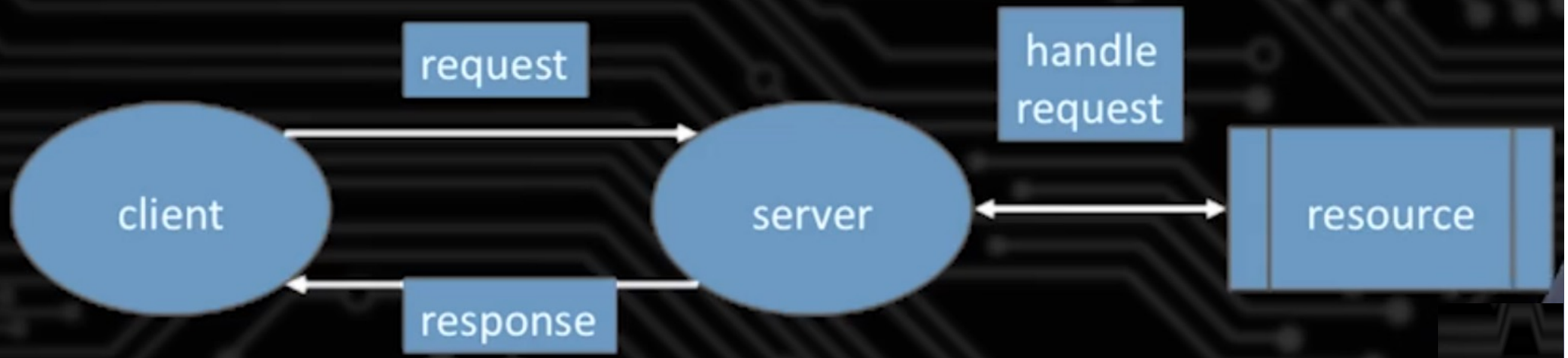
Networking & Internet

- **Explain the use of networking and basic networking hardware**
- **Describe the structure of the Internet**
- **Describe the meaning of a “network protocol"**
- **Explain MANETs and their relation to IoT**

Why Is Networking Needed?

- To enhance many devices
  - Cars communicating to reduce traffic
  - On-line game play
  - Access media libraries
- To access data or computational power outside of the device

Client-Server Transactions



Client-server model is very common

- Single server, one or more clients
- Server provides a service for clients
- Server manages a resource
- Server responds to requests from the client

Computer Networks: LAN

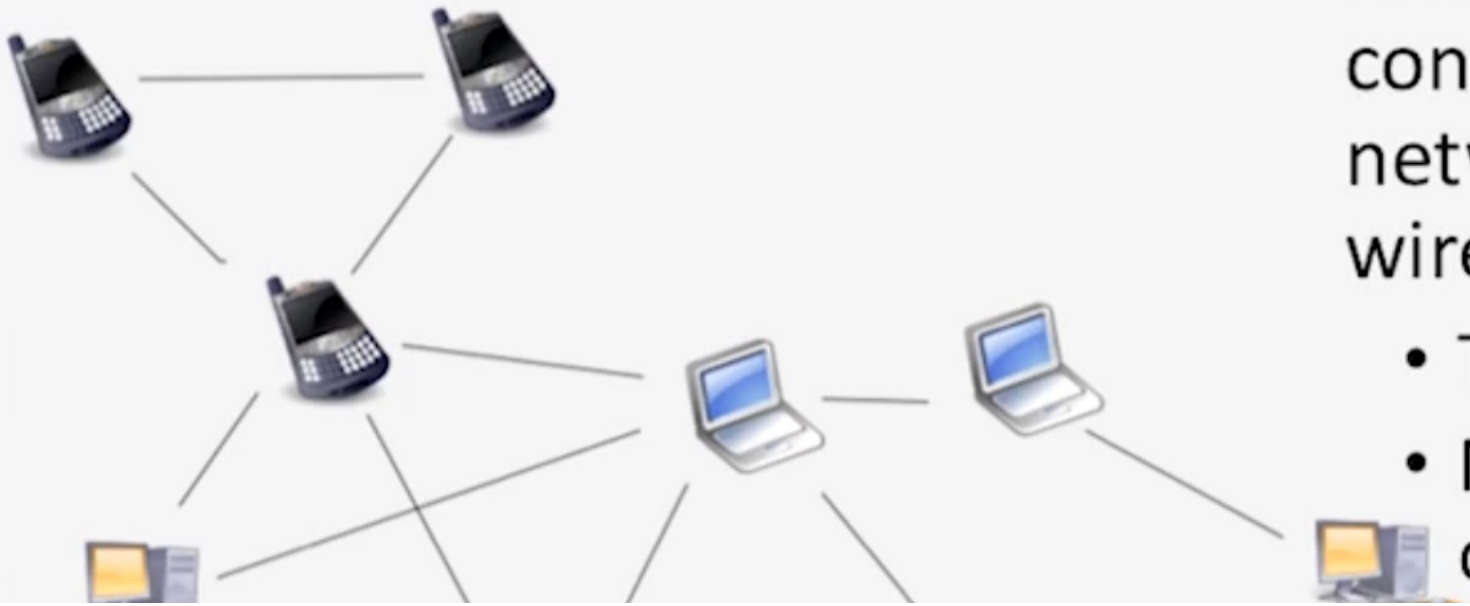
Hierarchical system of computer-based devices which communicate

- **Local Area Network (LAN)** – spans a building or campus (Ethernet is most common)

Computer Networks: WAN

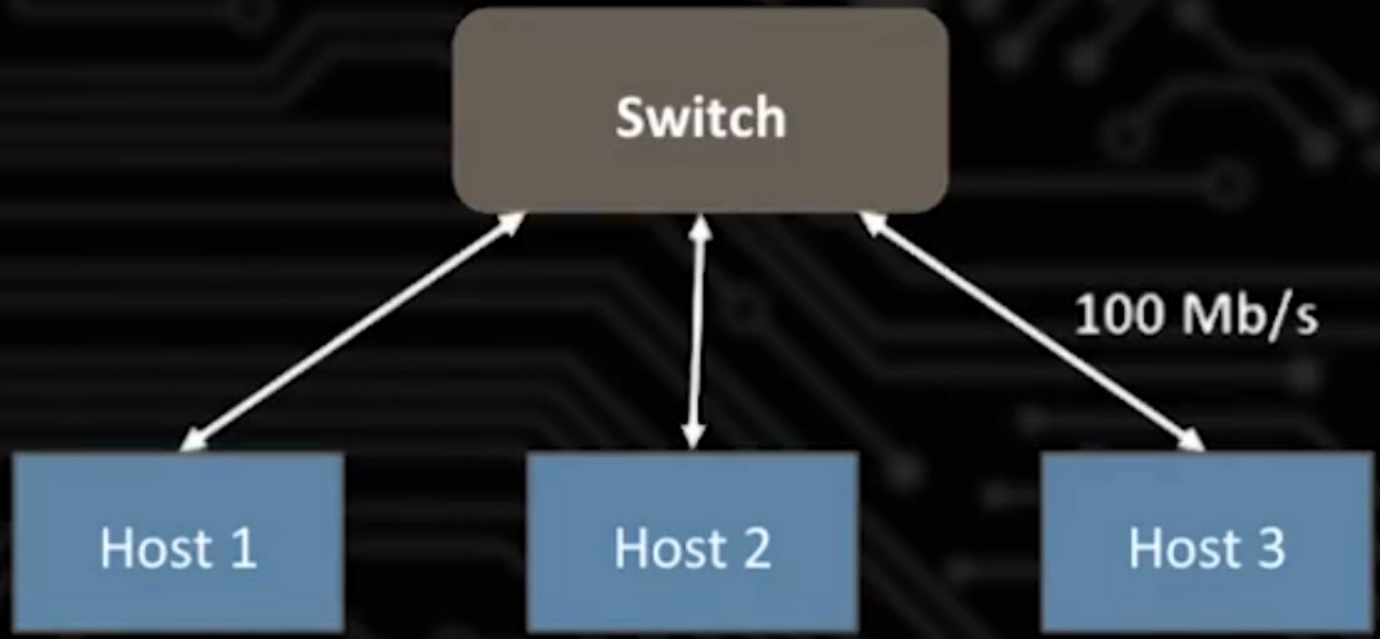
Wide Area Network (WAN) – Internet is best example

Computer Networks: MANET



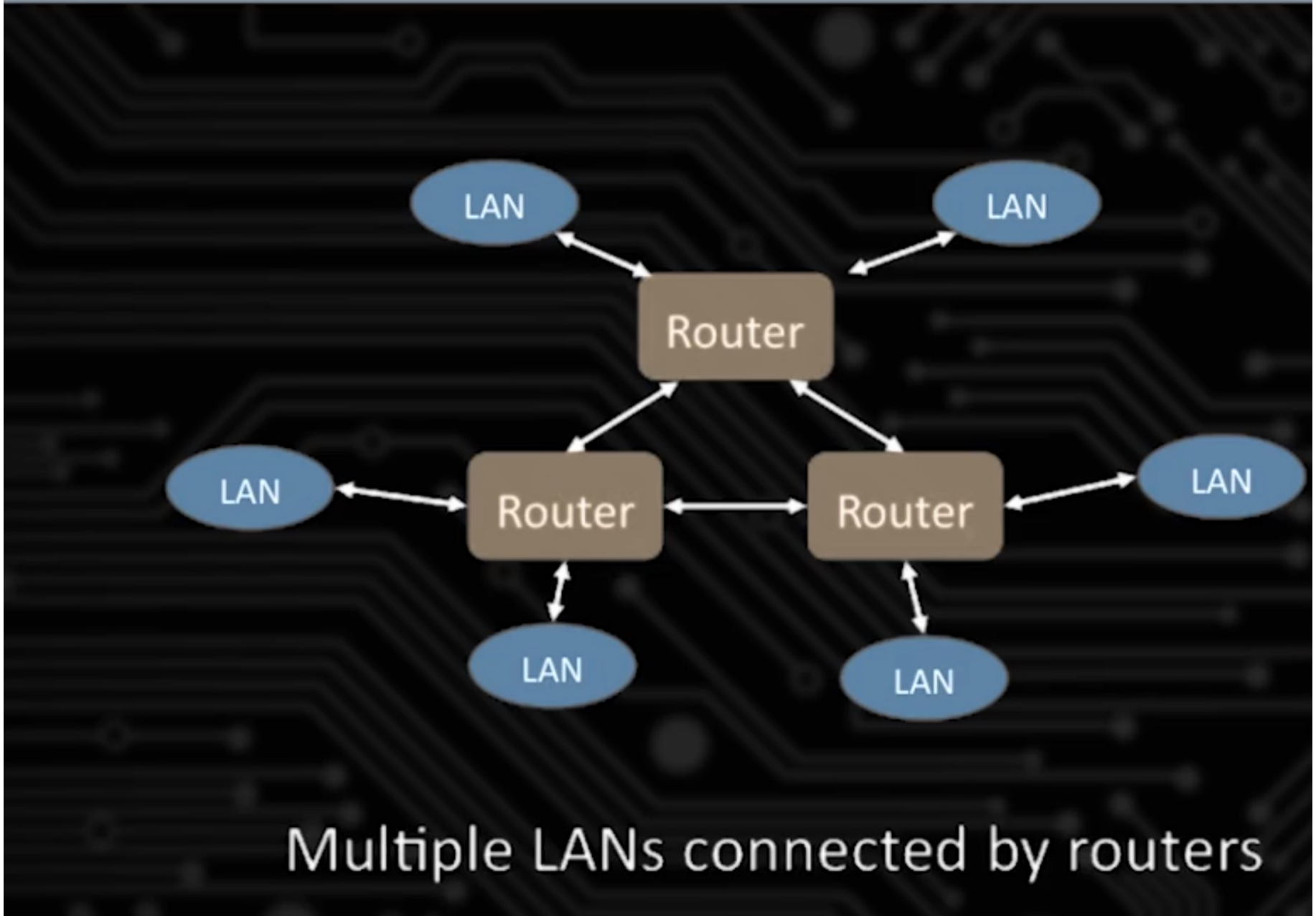
- **Mobile Ad Hoc Network (MANET)** – continually changing network built from wireless, mobile devices
  - Typically short-range
  - Most common for IoT devices

A Small LAN

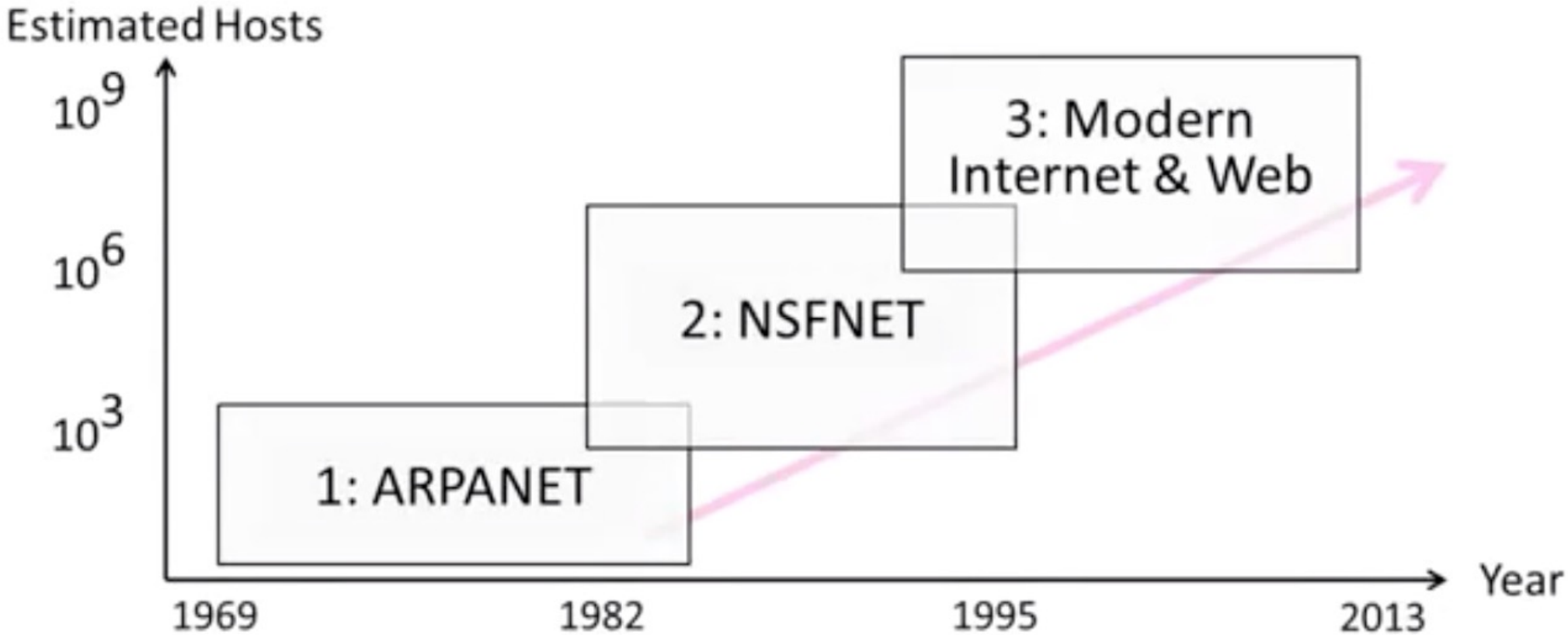


- Ethernet is a common LAN **protocol**
- Ethernet switch sends messages to the right input or output

A Wide Area Network



Rough Internet Timeline



The Beginning – ARPANET

- ARPANET by U.S. DoD was the precursor to the Internet
  - Motivated for resource sharing
  - Launched with 4 nodes in 1969, grew to hundreds of hosts
  - First “killer app” was email

ARPANET – Influences

- Leading up to the ARPANET (1960s):
  - Packet switching (Kleinrock, Davies), decentralized control (Baran)

Paul Baran

Credit: Internet Hall of Fame

Donald Davies

Credit: Internet Hall of Fame

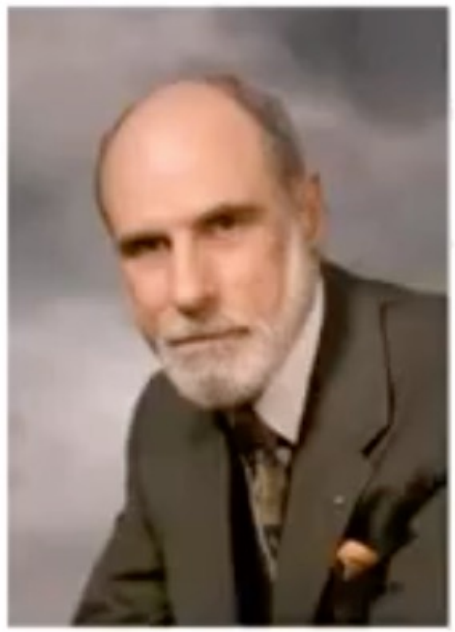
Len Kleinrock

Credit: Internet Hall of Fame

ARPANET – Influences (2)

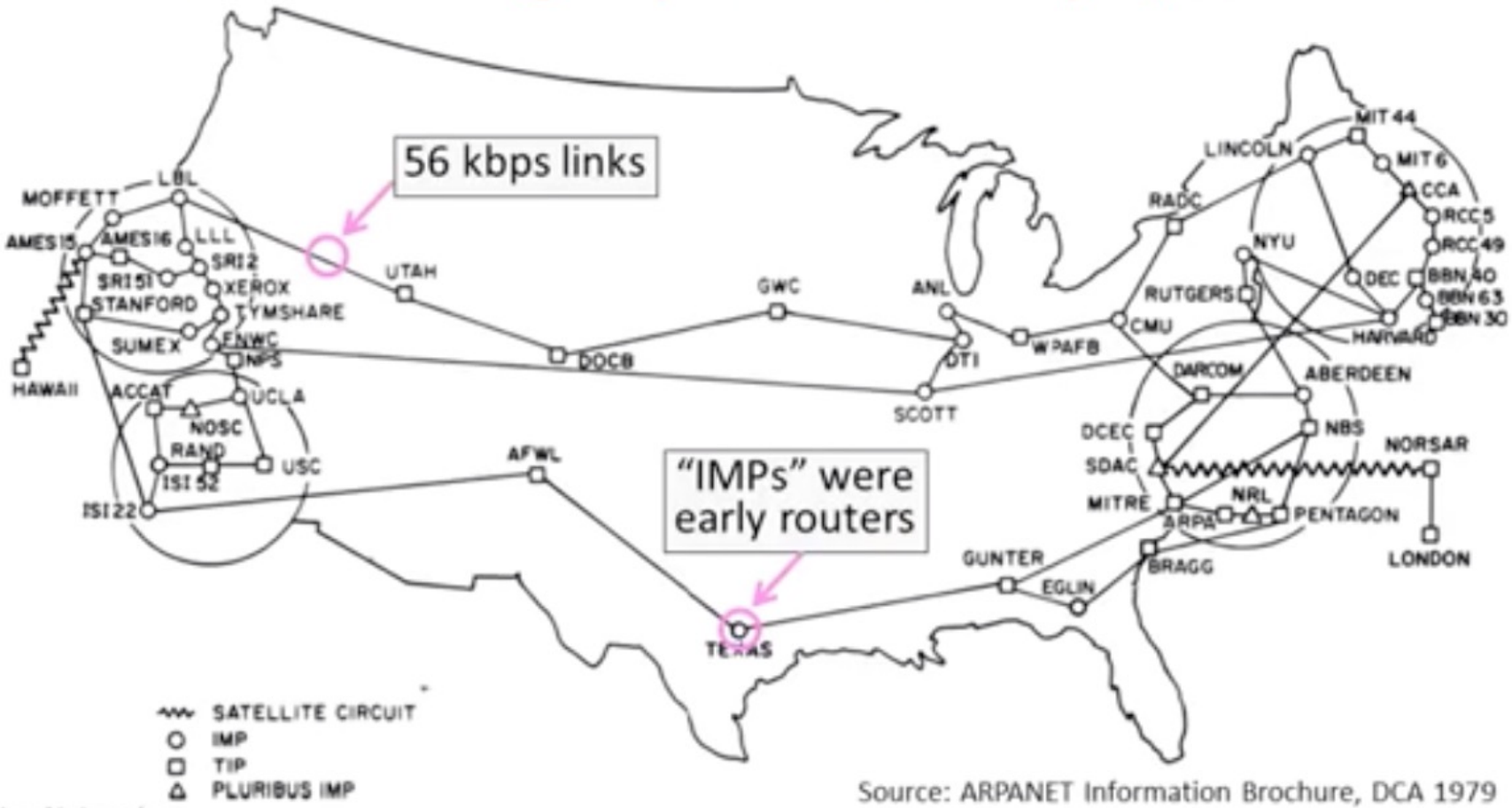
- In the early ARPANET
  - Internetworking became the basis for the Internet
  - Pioneered by Cerf & Kahn in 1974, later became TCP/IP
  - They are popularly known as the "fathers of the Internet"

Vint Cerf

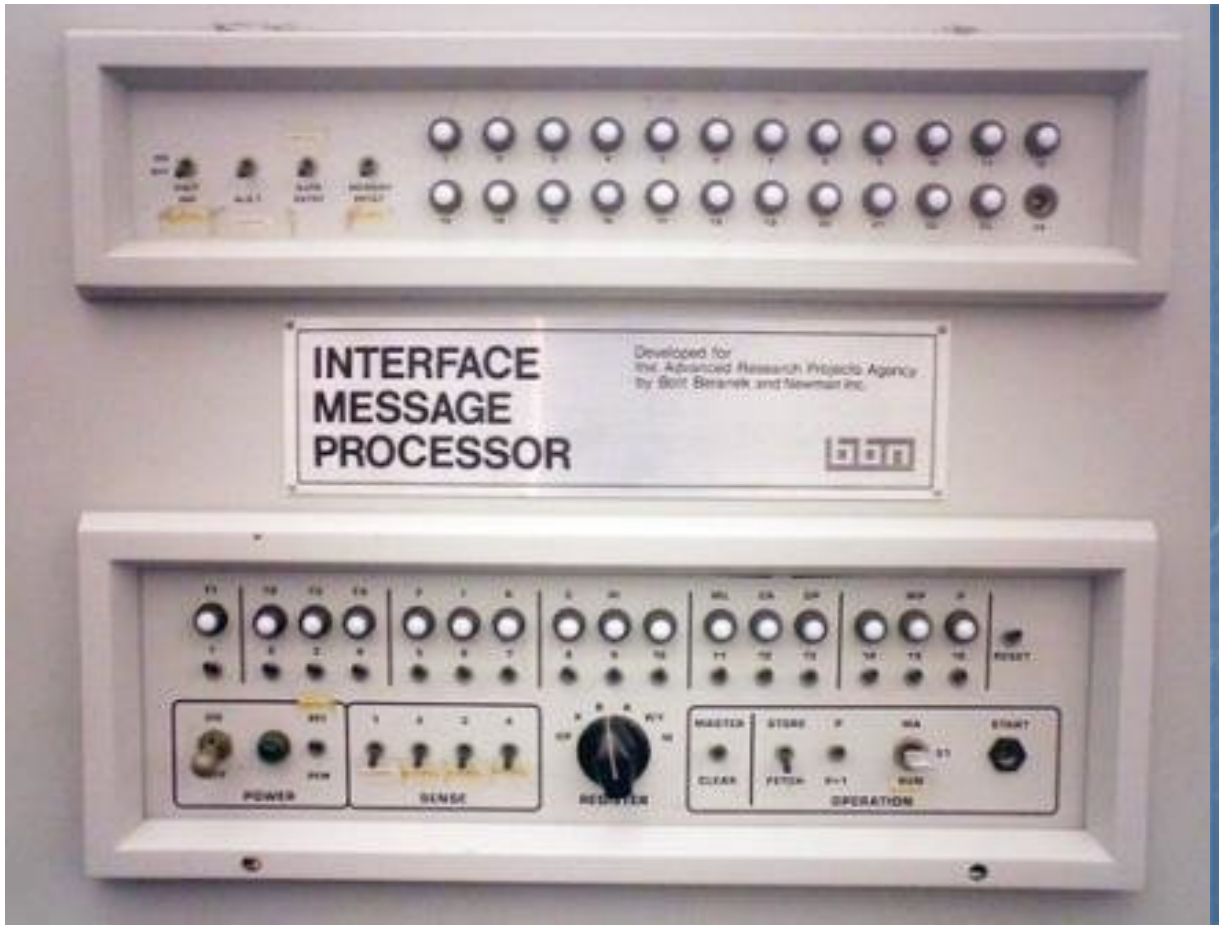


Bob Kahn

ARPANET Geographical Map (Dec. 1978)



Source: ARPANET Information Brochure, DCA 1979



(It's another cool artifact of history in the back room, awaiting installation in the new Computer History Museum exhibition hall.)

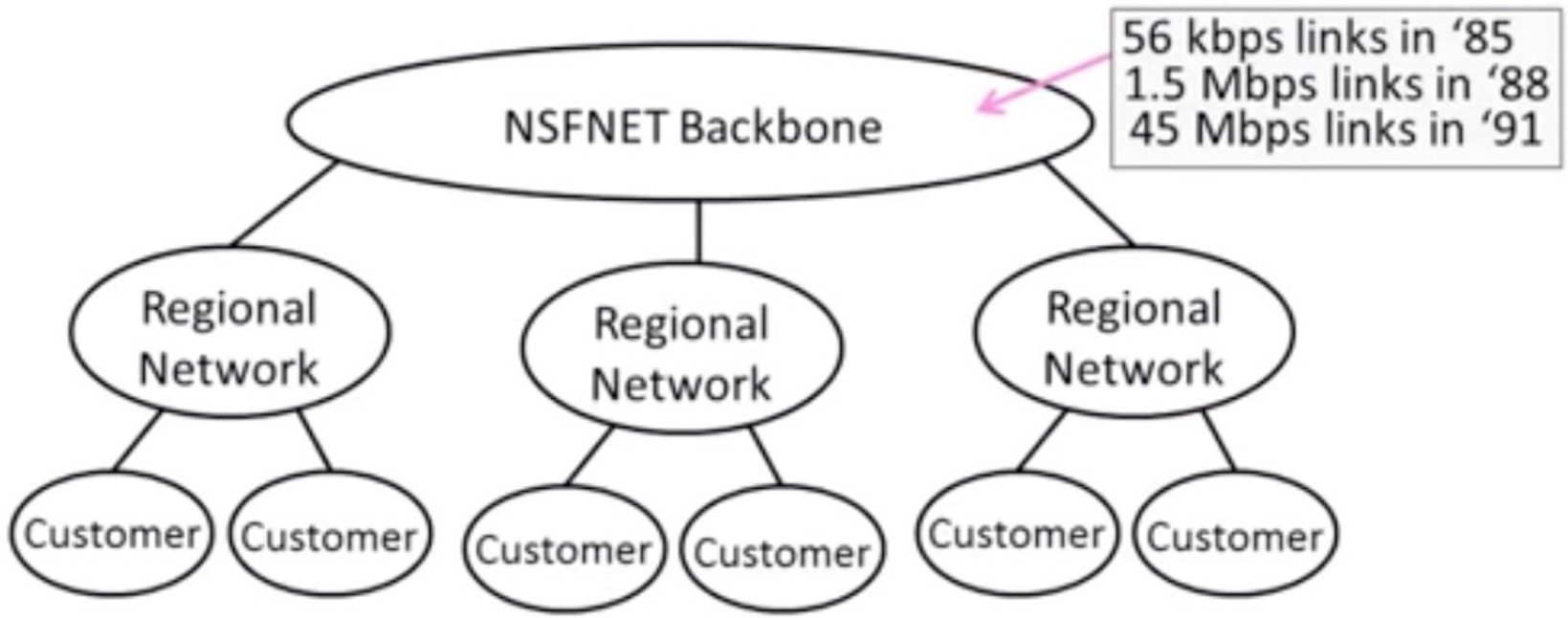
Leonard Kleinrock

Growing Up – NSFNET

- NSFNET ’85 supports educational networks
  - Initially connected supercomputer sites, but soon became the backbone for all networks
- Classic Internet protocols we use emerged
  - TCP/IP (transport), DNS (naming), Berkeley sockets (API) in ’83, BGP (routing) in ’93
- Much growth from PCs and Ethernet LANs
  - Campuses, businesses, then homes
  - 1 million hosts by 1993 …

Early Internet Architecture

- Hierarchical, with NSFNET as the backbone



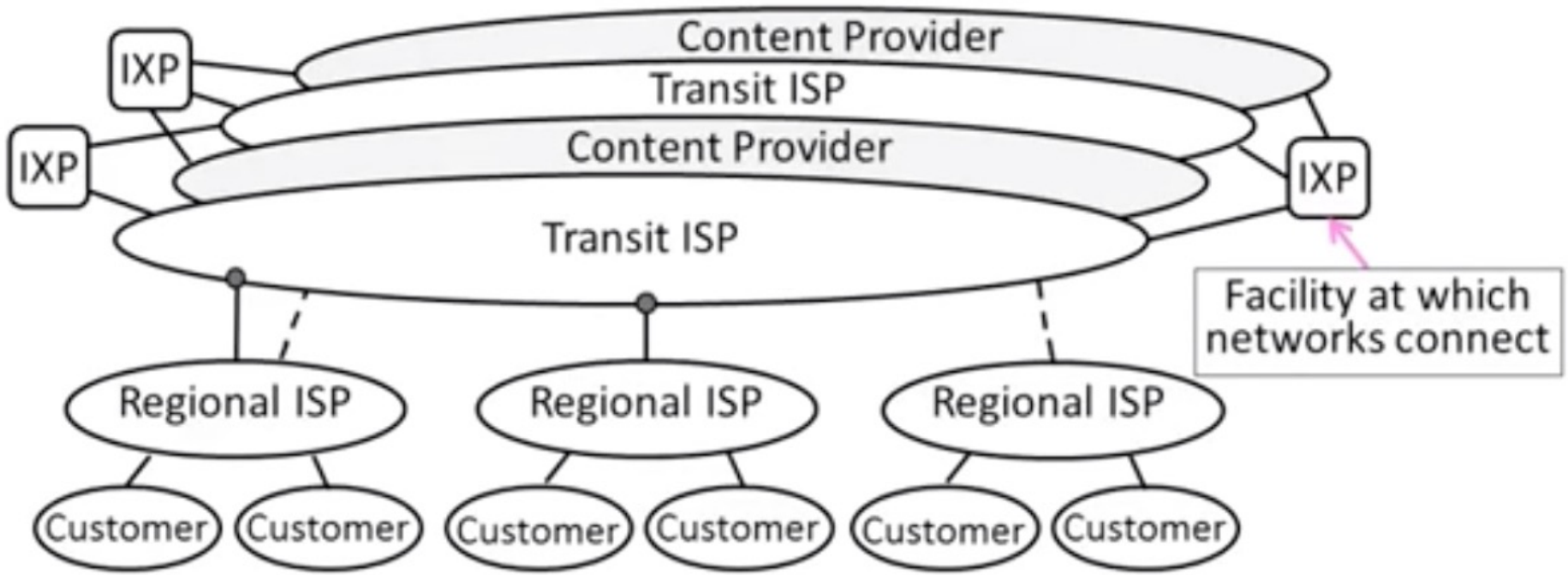
Modern Internet – Birth of the Web

- After ’95, connectivity is provided by large ISPs who are competitors
  - They connect at Internet eXchange Point (IXP) facilities
  - Later, large content providers connect
- Web bursts on the scene in ’93
  - Growth leads to CDNs, ICANN in ‘98
  - Most bits are video (soon wireless)
  - Content is driving the Internet

Tim Berners-Lee

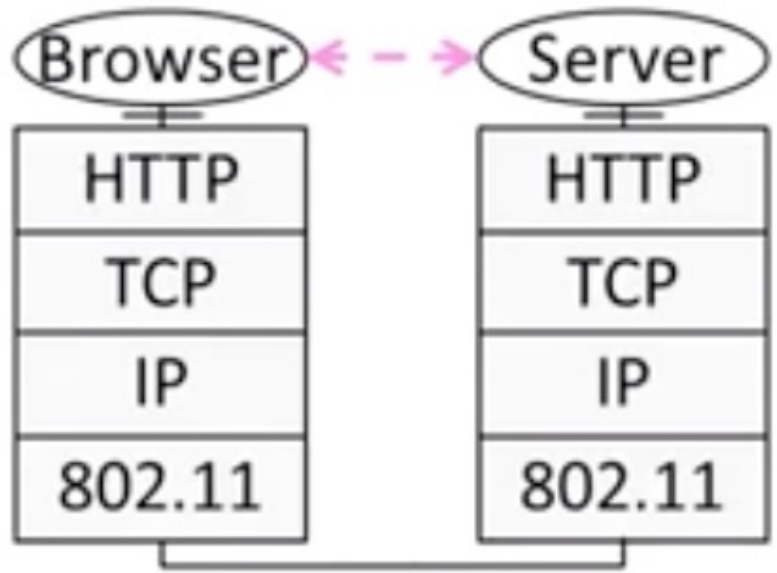
Modern Internet Architecture

- Complex business arrangements affect connectivity
  - Still decentralized, other than registering identifiers



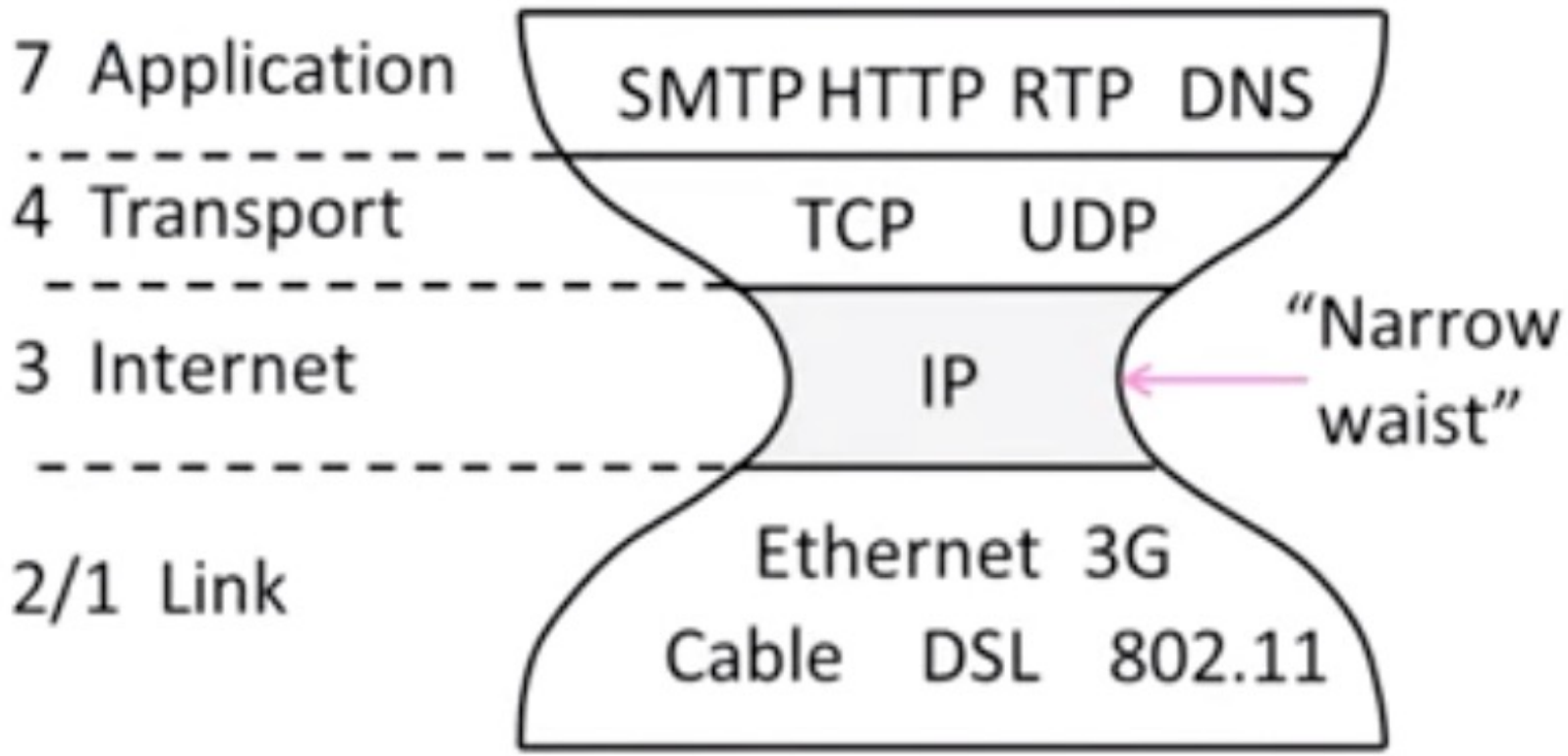
Protocols and Layering

- We've covered the key organizing structure of networks ☺
  - Now you know diagrams like this:



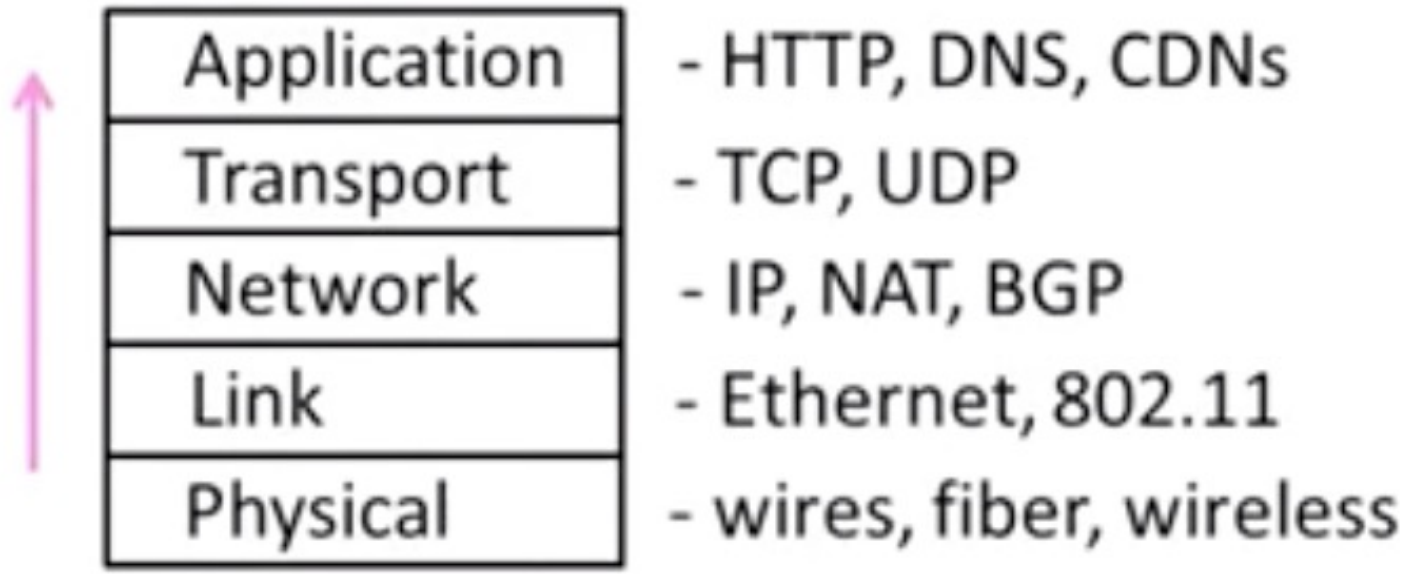
Protocols and Layering

- And you've seen how the internet protocols are organized:



Protocols and Layering

- Bottom-up through the layers:



- Followed by more detail on:
  - Quality of service, Security (VPN, SSL)

Internet Protocol Do?

Provides a naming scheme

- An internet protocol defines a uniform format for host addresses
- Each host (and router) is assigned at least one of these unique internet addresses