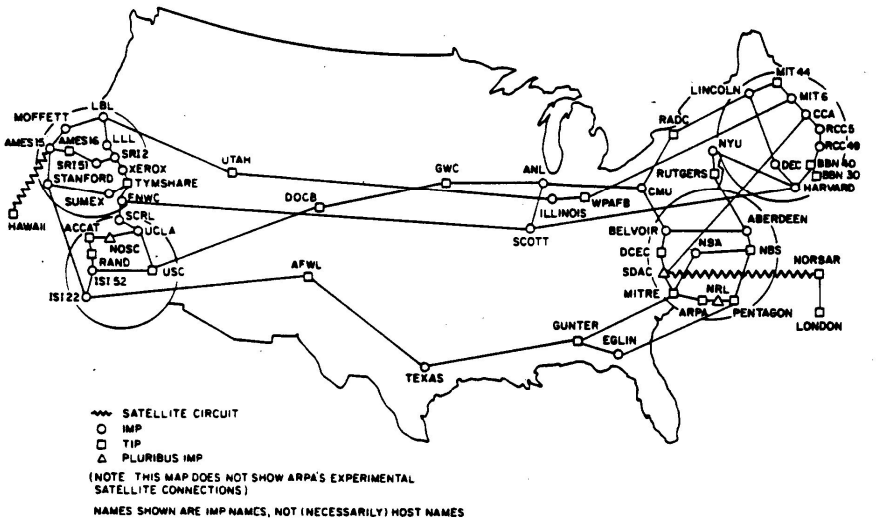
# ARPANET

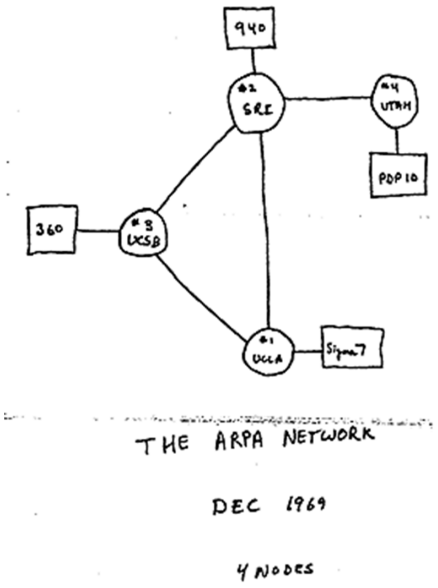
- ARPANET was developed to provide a test bed for researching packet-switching networks
  - Developed in the late 1960s; it was the first major effort to interconnect computers across a Wide Area Network (WAN)
  - For Packet-Switching Research:
    - Packet = Header + Data
    - ARPANET = Packet Switches + 56 Kbps Leased Lines
    - Distributed Routing
    - Congestion Control
    - Flow Control
  - ARPANET led to many innovations:
    - The TCP/IP protocols as the basis for Internet
    - Several lasting applications such as Email, remote login, file transfer



# What did ARPANET look like?



## What did ARPANET look like?





ARPANET Birthday: Oct. 29, 1969

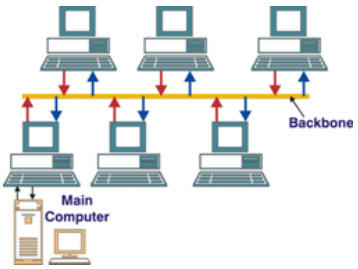


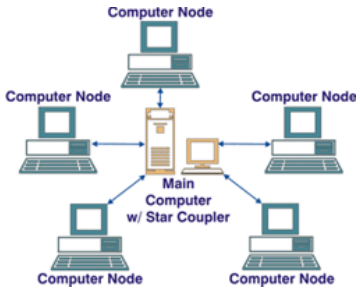
## Local Area Network (LAN)

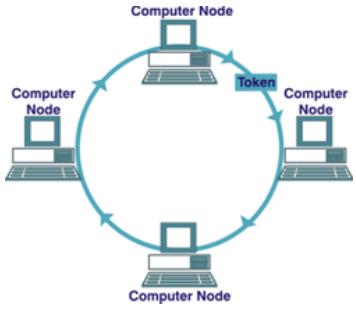
- In 1980s, affordable computers become available
- Need for low-cost, high-speed networks
  - to interconnect local computers
  - to access locally shared resources (e.g., printers, storage, servers)

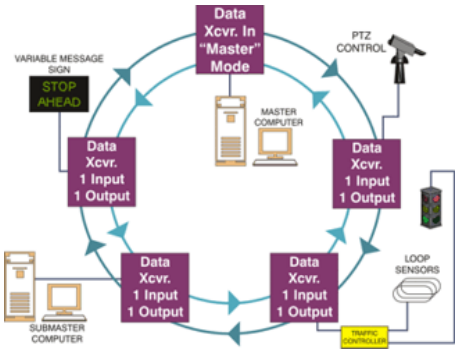
- Networks with limited distances (< 1 km) are called LANs
  - Short distance → high-speed communication with low error rate over cheap coaxial cable becomes possible
  - Messages are broadcasted to all machines in the LAN
    - Network Interface Card (NIC) of each machine has a globally unique address
    - A Medium Access Control (MAC) protocol becomes essential to coordinate access to the transmission medium

# Various LAN Topologies



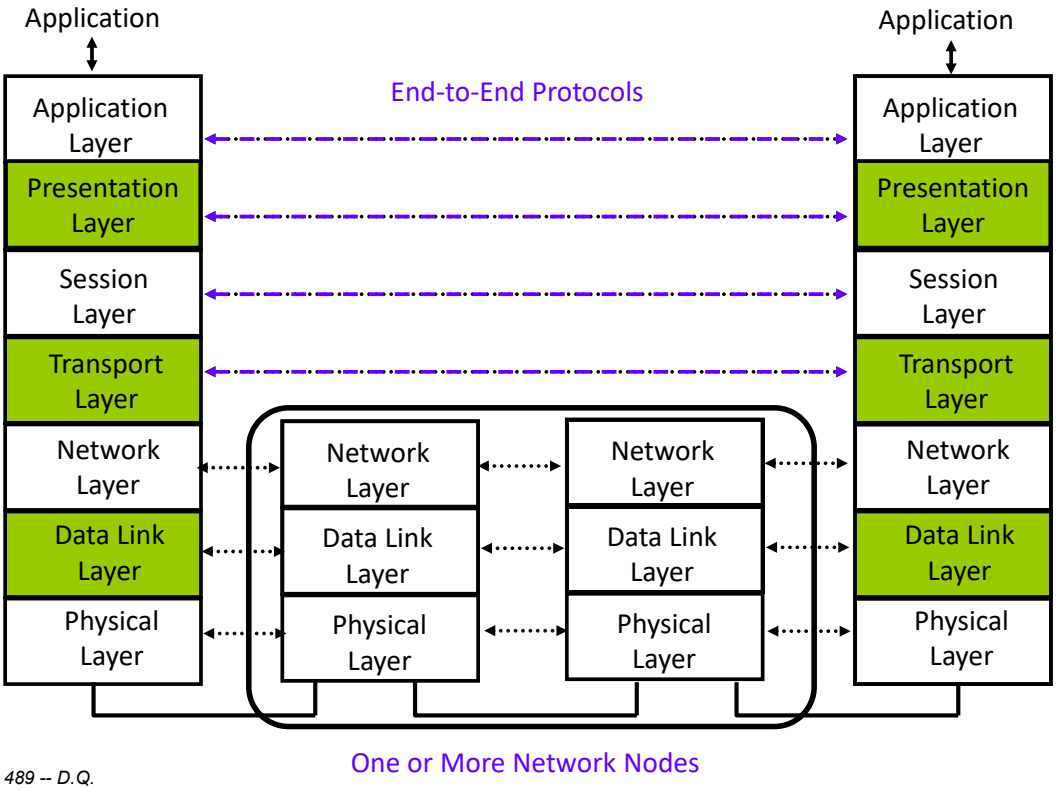





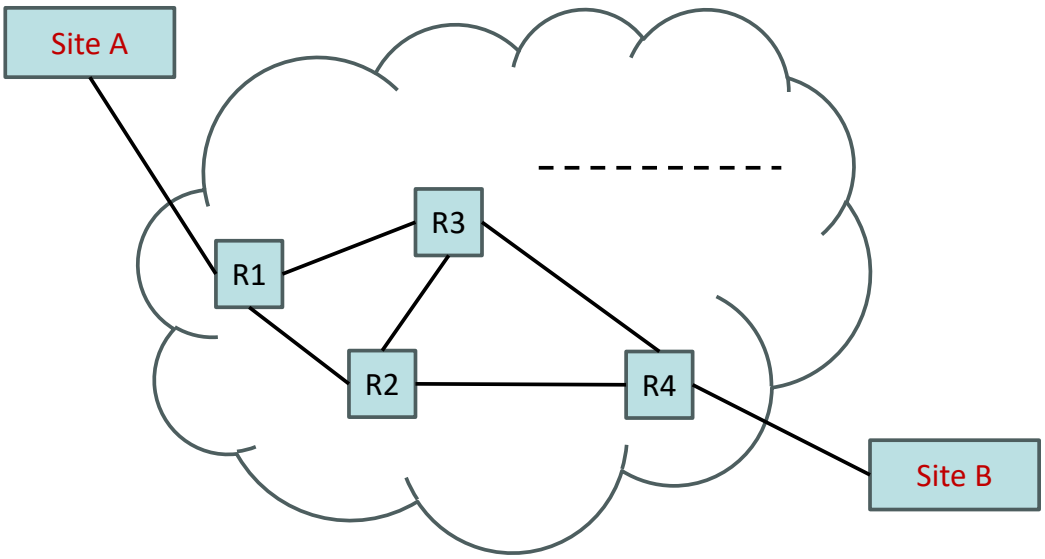

# The OSI Reference Model

- OSI (Open System Interconnection) Model
  - developed by ISO (International Organization of Standardization)
  - describes a 7-layer abstract reference model for a network architecture
  - provides a common framework for the development of standard protocols

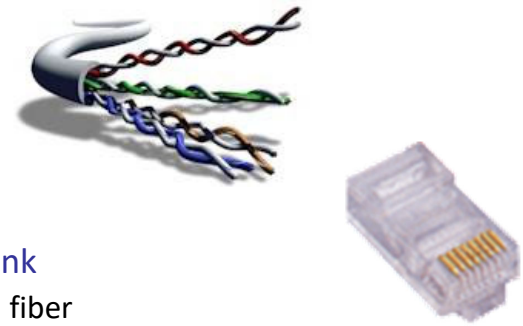
# 7-Layer OSI Reference Model





## Physical Layer (Layer 1)

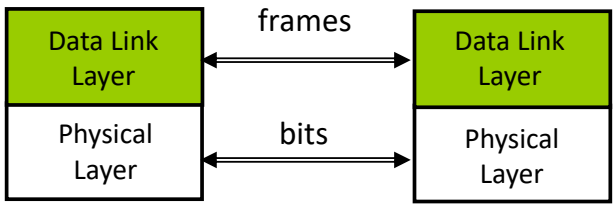


- Transfers bits across a communication link
  - Twisted-pair cable, coaxial cable, optical fiber
  - Radio, infrared, …
- Definition and specification of the physical aspects of a communication link
  - Mechanical: cable, plugs, pins...
  - Electrical/optical: modulation, signal strength, voltage levels, …
  - Functional/procedural: how to activate, maintain, and deactivate physical links, …



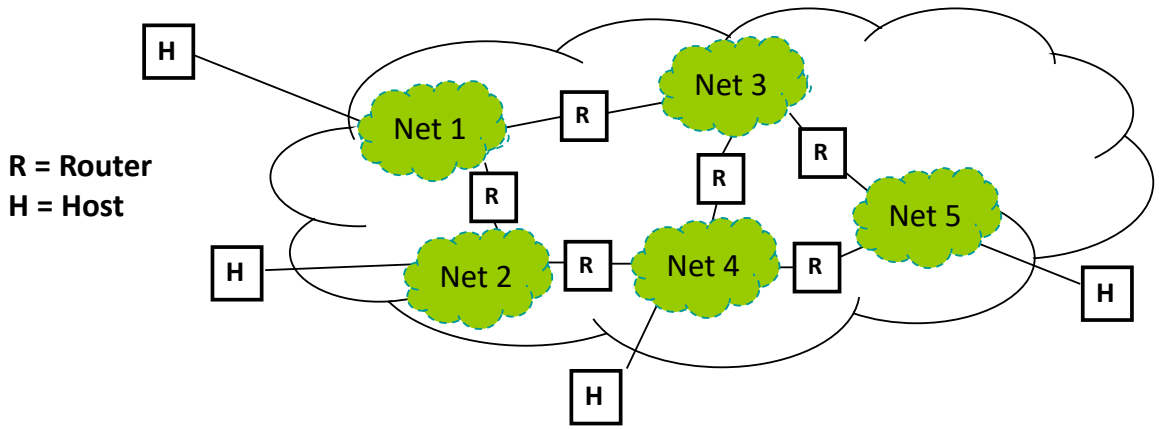
## Data Link Layer (Layer 2)

- Transfers frames across direct connections
- Framing: groups bits into frames
- Detection of bit errors; retransmission of frames
- Flow Control
- Medium Access Control for LANs (Local Area Networks)



## Network Layer (Layer 3)

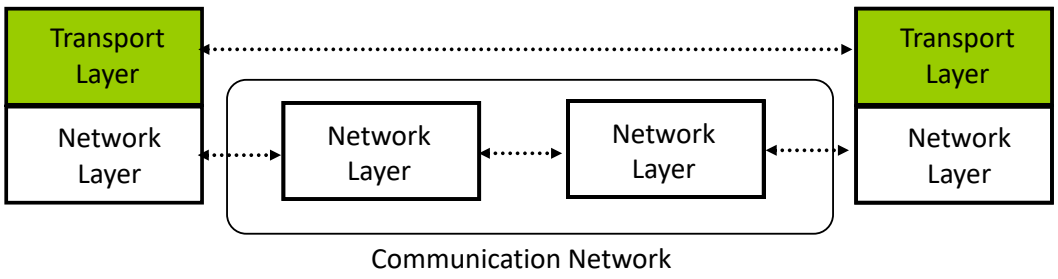
- Transfers packets across multiple links and/or multiple networks
- Addressing must scale to large networks
- Nodes jointly execute routing algorithm to determine paths across the network
- Best-effort connectionless service (no guarantee)





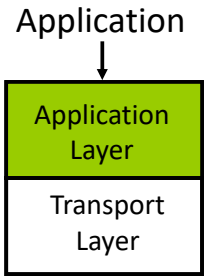

## Transport Layer (Layer 4)

- Transfers segments from process in one machine to process in another machine (end-to-end transfer)
- Reliable stream transfer or quick-and-simple single-block transfer
- Port numbers enable multiplexing
- Connection setup, maintenance, and release
- Congestion control, flow control



## Upper Layers (Layers 5, 6, 7)

- Application Layer: provides services that are frequently required by applications – DNS, web access, file transfer, email, …



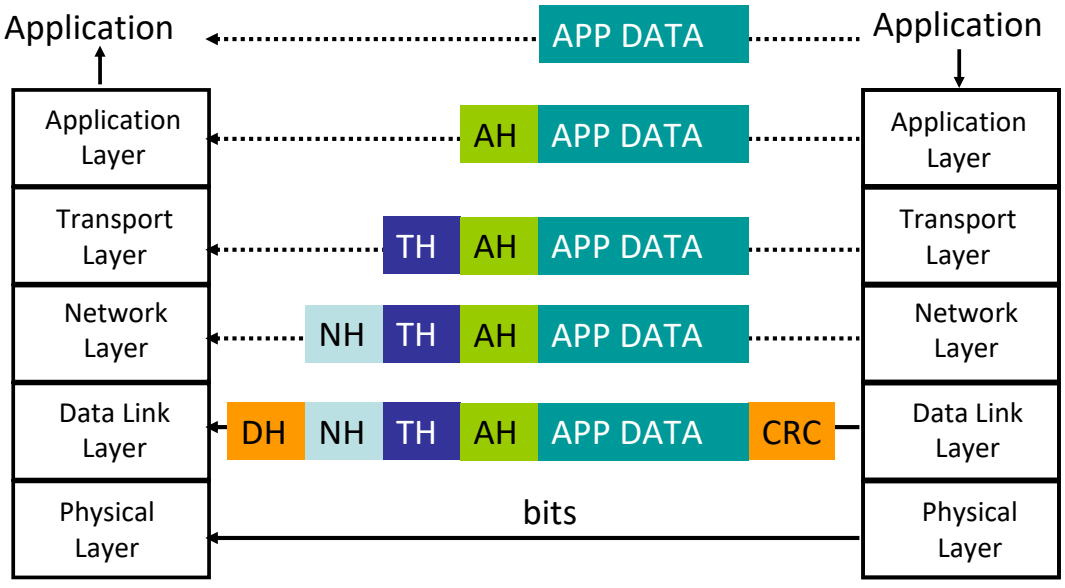

- Presentation Layer: machine-independent representation of data, …
- Session Layer: dialog management, recovery from errors, …

Been incorporated into Application Layer

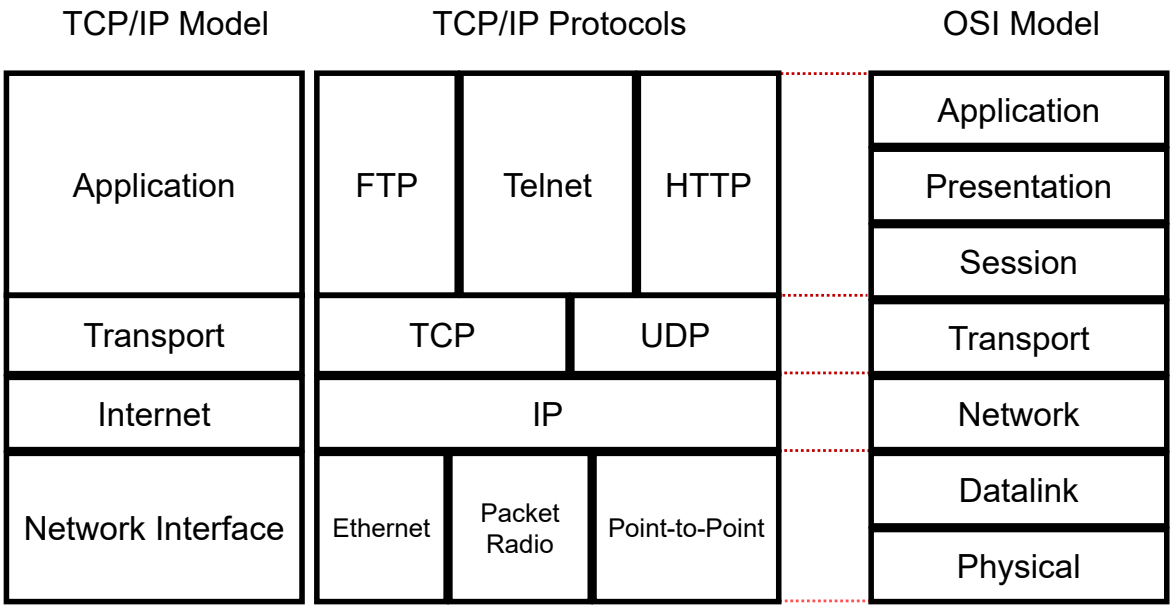


## Headers & Trailers

- Each protocol uses a header to carry control information such as addresses, sequence numbers, flag bits, length indicators, etc.
- CRC check bits are appended at Data Link Layer for error detection

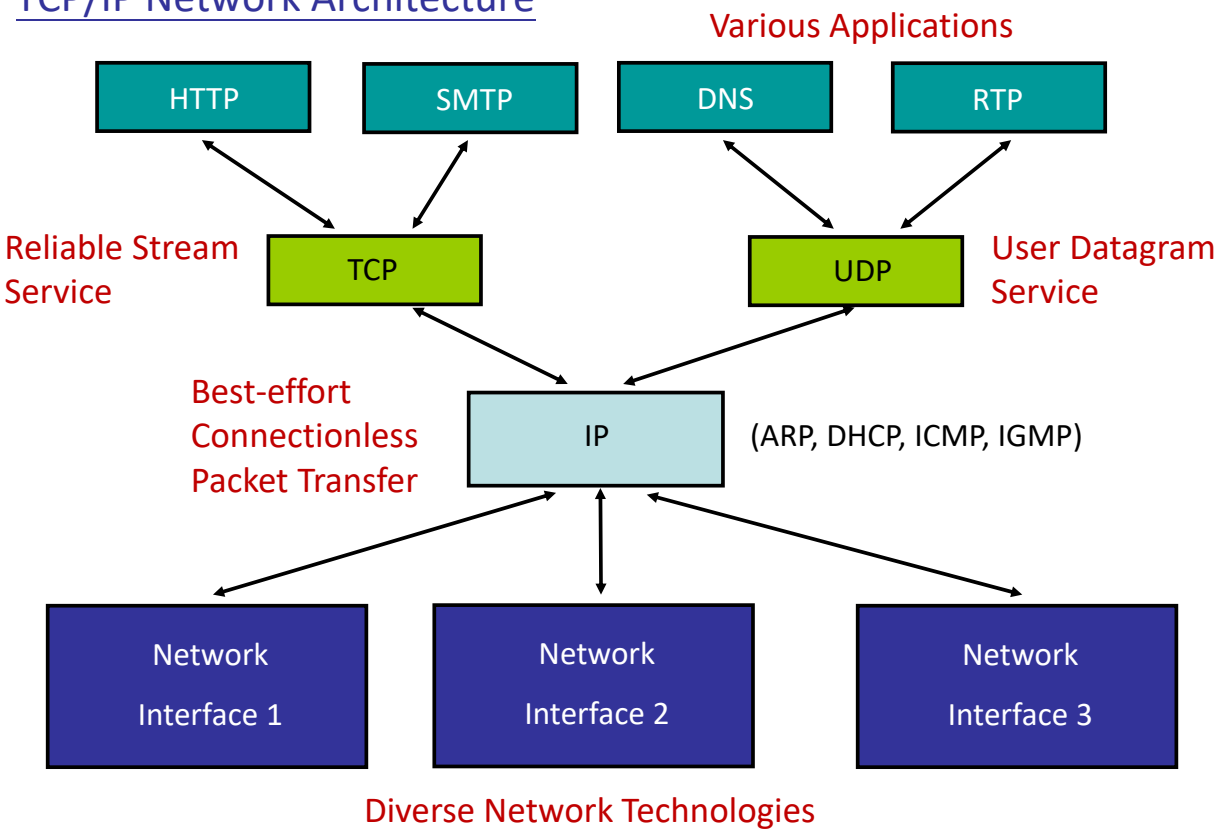


## TCP/IP Network Architecture






## TCP/IP Network Architecture



## Features of the Internet

- It is a digital transmission system
  - Information is converted to symbols (zeros and ones)
  - Transmission system is designed to convey symbols
- It is a packet-switching network
  - Transfer mode: packet switching
- It is a global network of networks
  - WAN (Wide Area Network)
  - LAN (Local Area Network)
- It has a layered network architecture
  - OSI reference model
  - TCP/IP architecture