



Lecture 2: Networks, LANs, WANs, TCP/IP

Computer network and its motivations

■ Computer network

- ☐ A collection of computers
- ☐ Special hardware to connect the computers
- ☐ Special software to manage the network

■ Motivations and purposes

- ☐ Share hardware
- ☐ Share software
- ☐ Share data
- ☐ Others: geographical constraints, political issues, military considerations, etc.

History of the Internet

■ ARPNET

- J.C.R Licklider (MIT), 1960s, the “Galactic Network” idea: share computers (expensive), share and access information
- Larry Roberts’ team, 1967, finalized ARPANET plan (ARP – Advanced Research Project Agency, a U.S. Department of defense agency)
- Became reality, 1969, linking 4 computers at UCLA, UCSB, SRI (Stanford Research Institute), University of Utah
- Growth
 - 23 computers in 1971
 - 100 computers by 1980
 - More than 1,000 computers by 1984

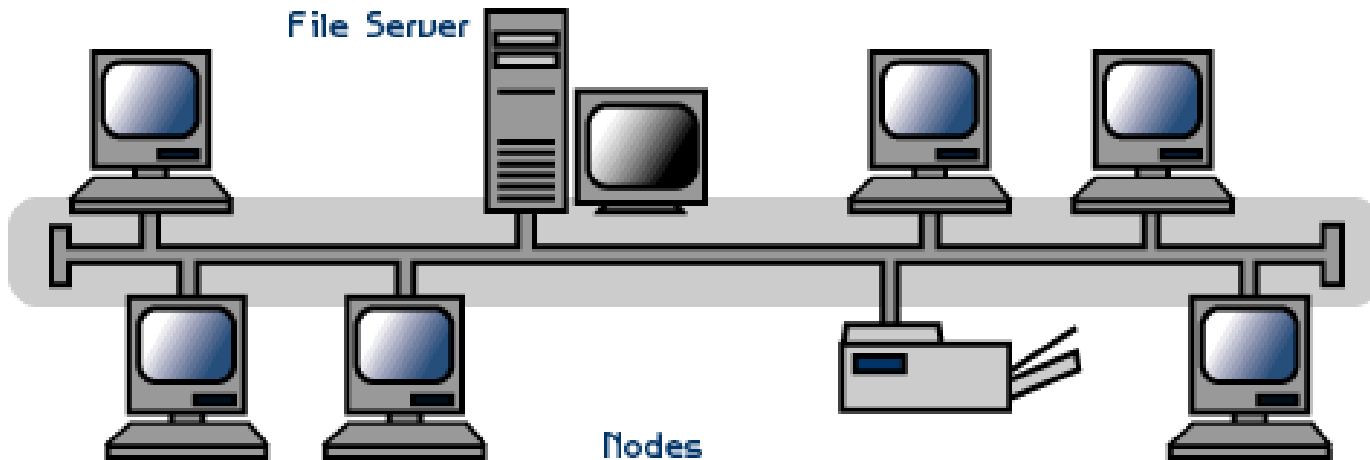
■ Internet

- NSF (National Science Foundation) became involved in ARPNET in 1984 and NSFNET was created, and later becomes the backbone of Internet.
- In mid 1980s, the NSFNET became open to commercial interests
- In 1991, CA*net (Canadian) and CERN (European) were connected to the Internet backbone.
- Internet Society (ISOC) – Some nonprofit organizations
 - IETF (Internet Engineering Task Force)
 - IAB (Internet Architecture Board)
 - IESG (Internet Engineering Steering Group)
 - IRTF (Internet Research Task Force)

Types of networks

- LAN – Local Area Network
 - Connection: wire cable, wireless
 - Feasibility: a restricted (small) area, e.g. a room, or part of a building
 - Technologies: mostly Ethernet
- WAN – Wide Area Network
 - Connection: fiber optic cable, leased long-distance phone lines
 - Feasibility: a wide geographical area, e.g. Internet (all over the world)
 - Technologies: TCP/IP protocols over different hardware
- Others
 - PAN – Personal Area Network: smaller area than LAN, e.g. personal computer, telephone, PDA
 - MAN – Metropolitan Area Network: usually a collections of LANs, e.g. campus network

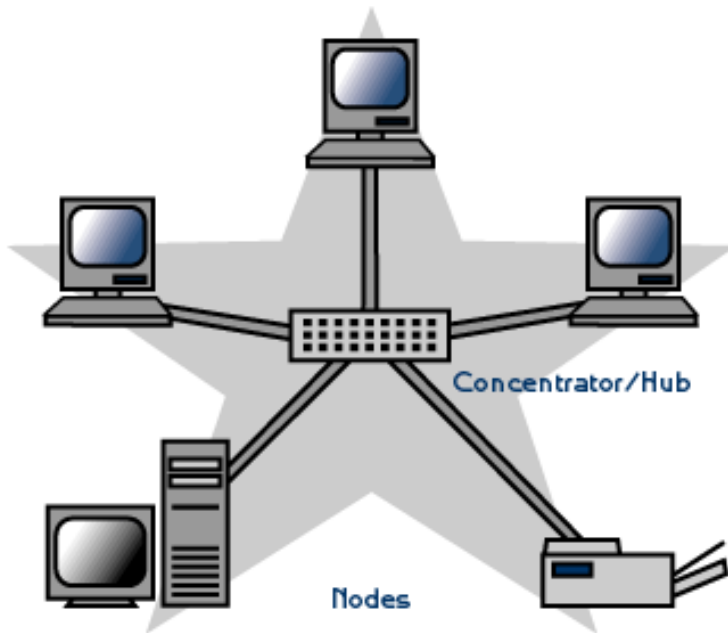
LAN example: Early Ethernet



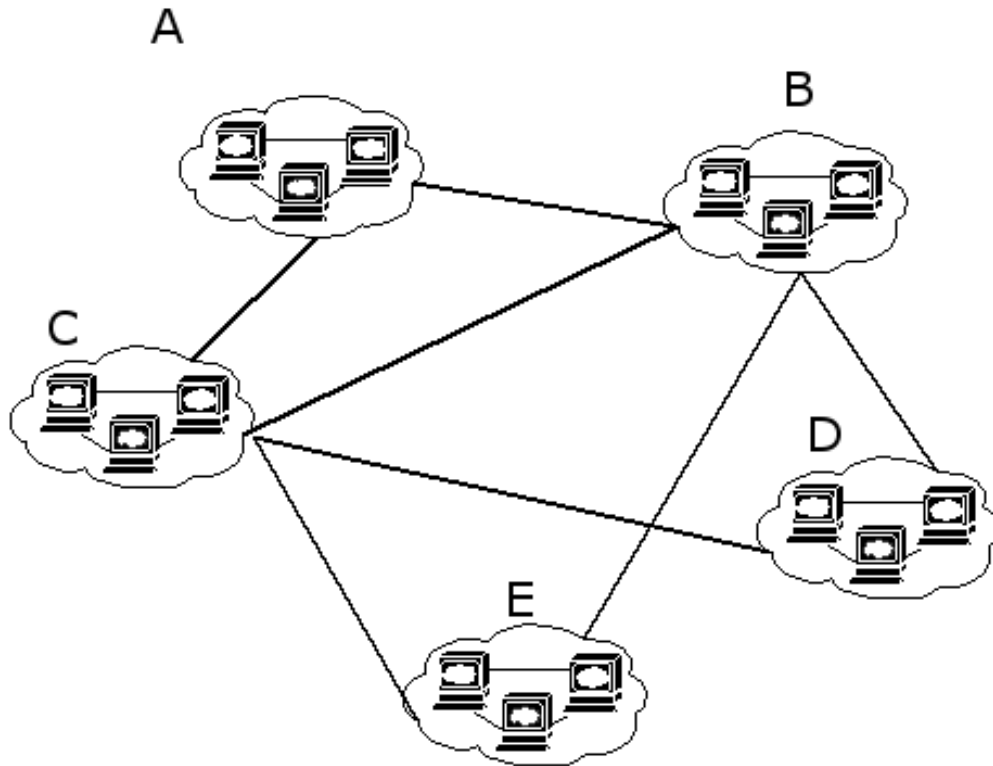
- Share a common communication channel (a line bus in the early days)
- Broadcast messages (frames)
- Each computer retrieves only the messages addressed to it, and drops all other messages
- Carrier sense multiple access with collision detection (CSMA/CD)

Star-topology Ethernet

- Line bus: The network shutdowns by a single break in the bus
- So star-topology



internetworking – WAN



- Connecting the different networks
- Multiple paths between networks



Robust and Distributed Networking

- ARPNET's military request for robust
 - Cold war period
 - Guarantee communication even parts of the network are damaged or destroyed
- Internet was developed as a decentralized distributed network

Identify computers and networks

- Within a LAN, each computer has a unique identifier, e.g. MAC address in Ethernet
- Within a WAN, each network has a unique identifier
- How to identify a computer in a WAN composed of LANs using different technologies? – IP address

IP (Internet Protocol) address

- IP address format: e.g. 146.245.1.122
 - 4 groups of numbers
 - Each number with range 0-255
 - Total number of IP: $256 * 256 * 256 * 256 = 4,294,967,296$ (4 billion)
- Each computer (or device) possesses an IP address
- Each subnet corresponds to a set of IP addresses with certain pattern
 - E.g. Brooklyn college has all the IP addresses of the pattern 146.245.*.*
 - SCI-network is 146.245.1.*
- A network structure can be defined no matter what underlying technologies are being used:
 - Computer (or network) device – IP address
 - A subnet – a pattern of IP addresses
 - Within a subnet, computers can communicate with each other directly
 - Across subnets, routers look up routing table to decide a path for the message



Packet switching

- Messages are broken into small pieces of packets
- Packets are sent independently to their destinations through different networks
- Original messages are reconstructed from packets at the destinations

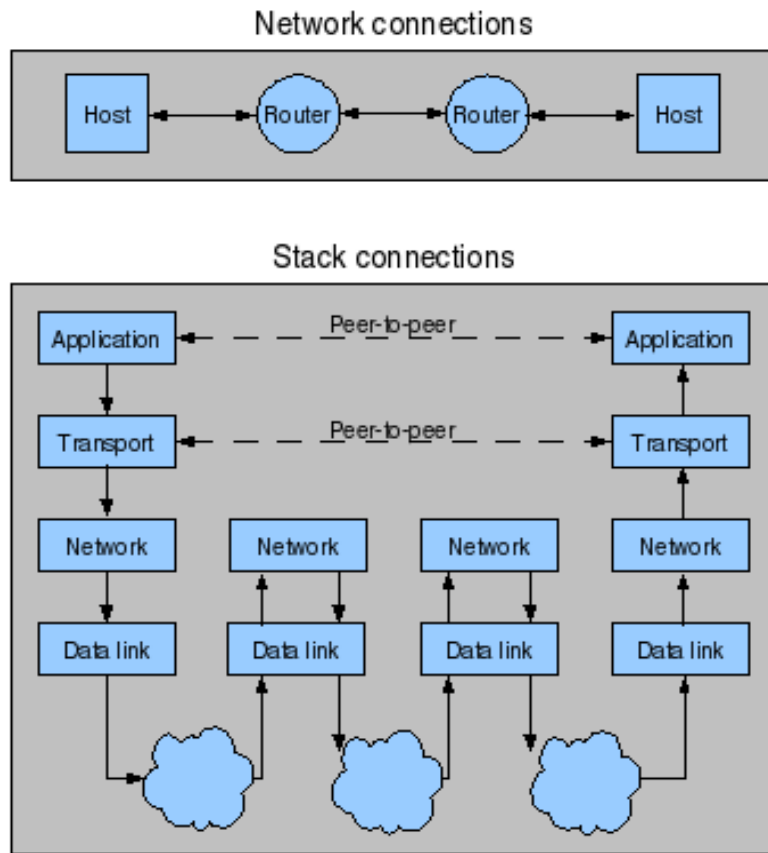
Advantages of Packet Switching

- Increase usage efficiency of connection
 - a large message monopolize the connection
- React to failures or congestion
 - Packets of the same message can go through different routes to the destination
- Increase reliability
 - Failures in transmitting different packets are independent
 - At least part of the messages will arrive the destination with high probability
 - Request retransmission of the missing packets

Communication protocol

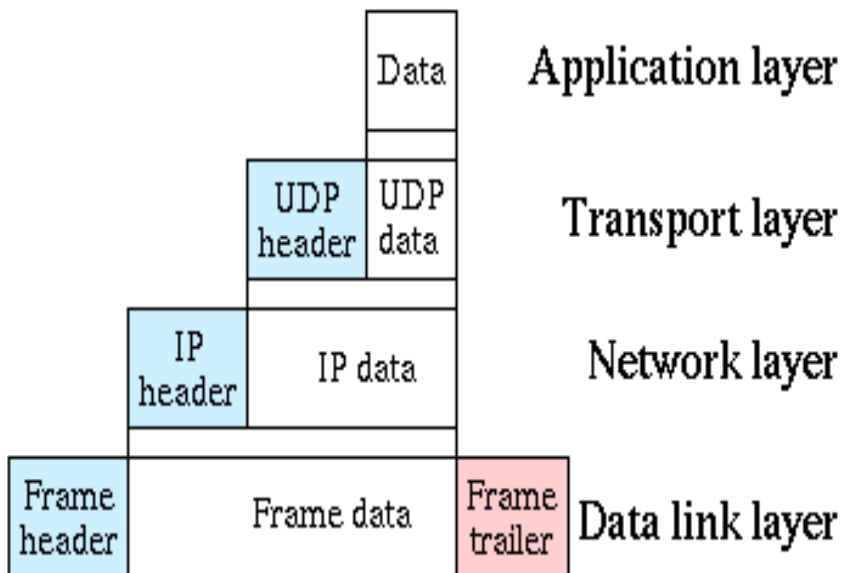
- A standardized set of rules to govern the network communication
- Interconnect different networks
- Router
 - Look up a routing table
 - Decide a route for a packet based on the source and destination of the packet
- RFC (Request for Comments), a series of numbered Internet informational documents and standards of or related to communication protocols

TCP/IP protocols



- Data link layer – e.g. Ethernet
- Network layer – e.g. IP packet exchanging
- Transport – e.g. TCP connections
- Application – e.g. HTTP

Datagram (an UDP example)



- MAC addresses in frame header
- IP addresses in IP header
- UDP ports in UDP header (a port is used to identify an application within a computer)
- Data is the information intended for transmission

Transfer rate

- **Transfer rate** is the average number of bits, characters, or blocks per unit time passing between equipments in communication.
- E.g.
 - 1bit/s: 1 binary bit per second
 - 1k bit/s: 1k (1024) binary bits per second
 - 1M bit/s: 1M (1024 * 1024) binary bits per second

DNS – Human friendly addressing

- IP address is hard to remember
- Domain name is used
 - Format: strings of letters, digits and hyphen separated by dots
 - E.g. merupu.sci.brooklyn.cuny.edu
 - The idea are similar to the mailing address in the postal system
- Domain Name System (DNS)
 - Map domain name to IP address
 - Map IP address to domain name (sometimes)

URL (Uniform Resource Locator)

<http://acc6.its.brooklyn.cuny.edu/~cis10/syllabus.html>

- http (Hyper Text Transfer Protocol) specifies the application protocol of transferring the resource
- acc6.its.brooklyn.cuny.edu specifies the location of the resource
- [~cis10](http://acc6.its.brooklyn.cuny.edu/~cis10) specifies the directory of the resource within the server
- [syllabus.html](http://acc6.its.brooklyn.cuny.edu/~cis10/syllabus.html) specifies the name of the resource under the directory in the server

A hierarchical organization approach!

Summary

- Motivation for networking
- LAN, WAN
- ARPNET and history of Internet
- Packet switching
- IP address
- Communication protocols, RFC, TCP/IP protocols
- Router
- DNS