Module 1

(Data communication Components: Representation of data and its flow Networks, Various Connection Topology, Protocols and Standards, OSI model)

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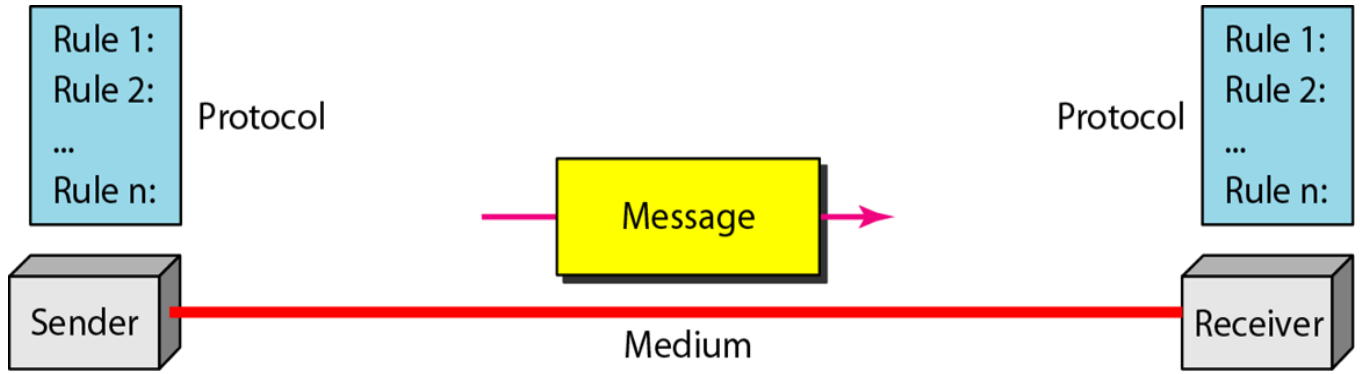
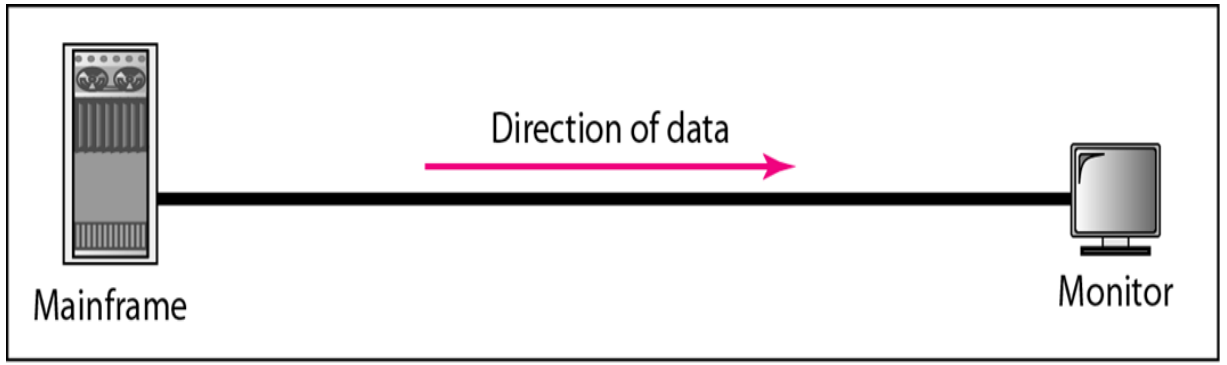
Data Communications & Components

- Telecommunication means communication at a distance.
- Data refers to information presented in whatever form, agreed upon by the parties generating and using the data.
- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.
- Four characteristics of data communication
  - Delivery; Accuracy; Timeliness; Jitter
- Five components
  - Message; Sender; Receiver; Medium; Protocol
- Network criteria
  - Performance; Reliability; Security

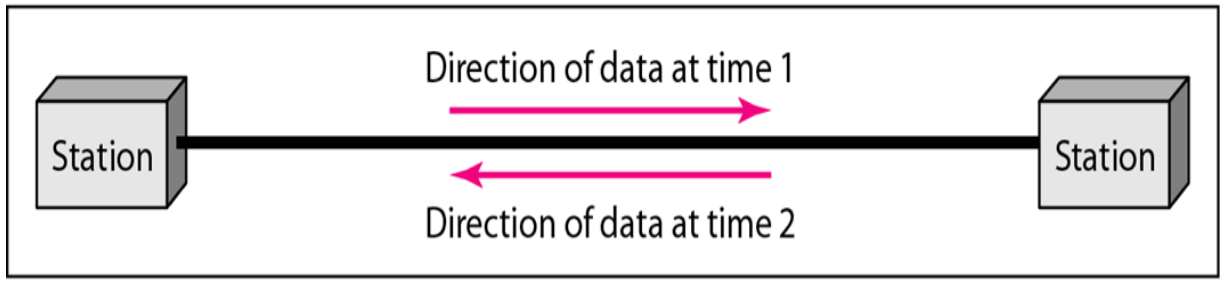


Data Flow

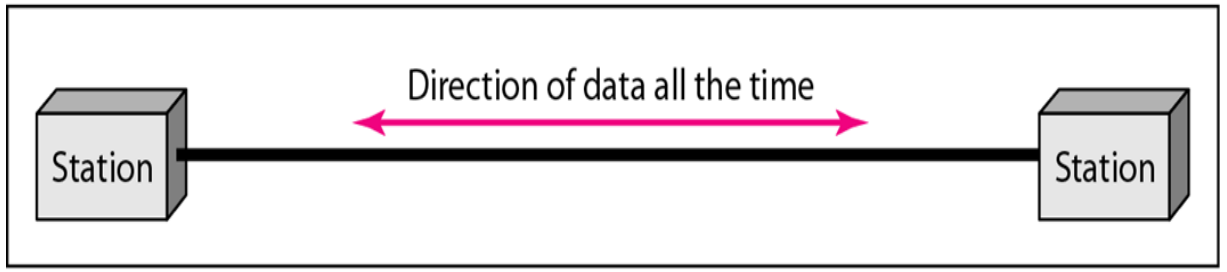
- Simplex
  - Communication is unidirectional
  - Uses the entire capacity of the channel to send the data
  - Example: keyboards, traditional monitors
- Half-duplex
  - Communication is bi-directional
  - Station can both transmit and receive, but not at the same time
  - Example: Walkie-talkies
- Full-duplex
  - Both stations can transmit and receive at the same time
  - Channel capacity is shared between the two directions
  - Example: Telephone line



a. Simplex



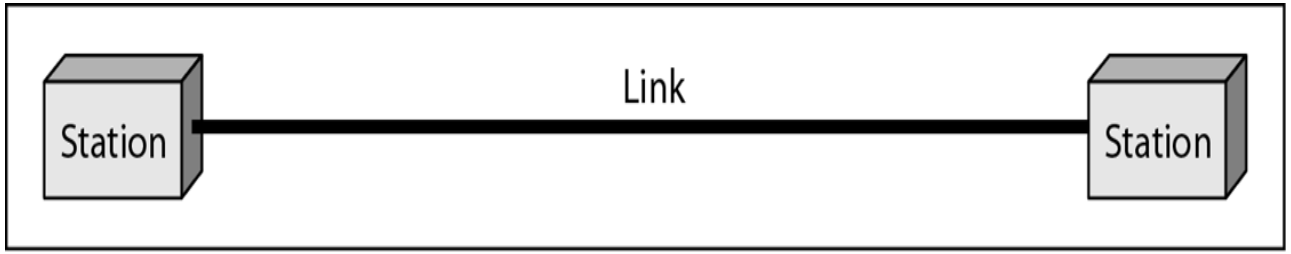
b. Half-duplex



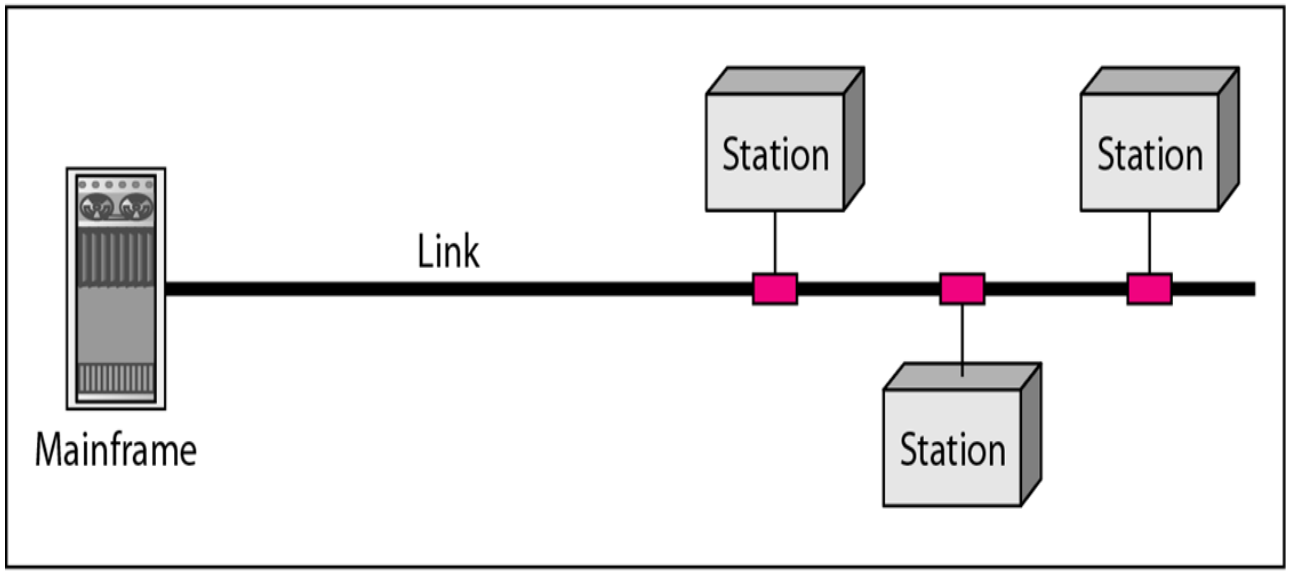
c. Full-duplex

Types of Connection

- Point-to-point
  - Provides a dedicated link between two devices
  - Entire capacity reserved for communication between those two devices
  - Example: Changing television channels by remote control
- Multipoint (Multidrop)
  - More than two devices share a link
  - Channel capacity is shared, either spatially or temporally.
  - If several devices can use the link simultaneously, it is a spatially shared connection.
  - If users must take turns, it is a timeshared connection.

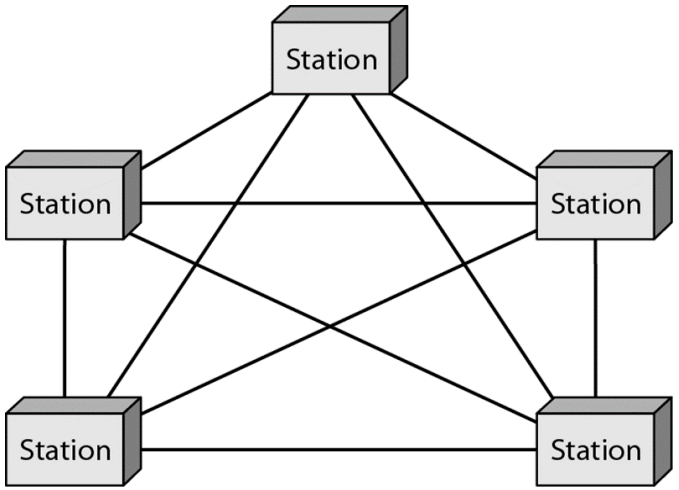


a. Point-to-point

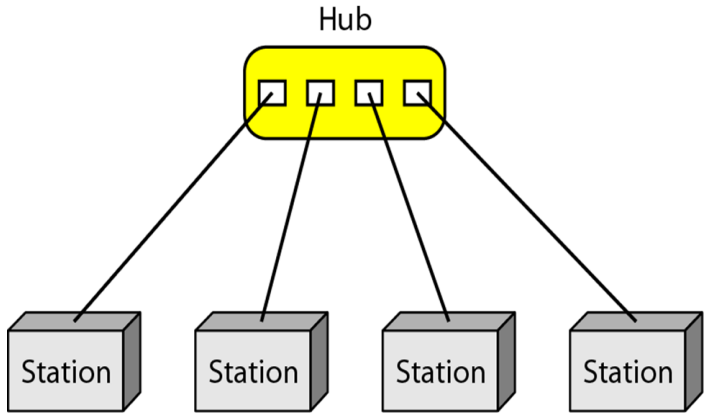


b. Multipoint

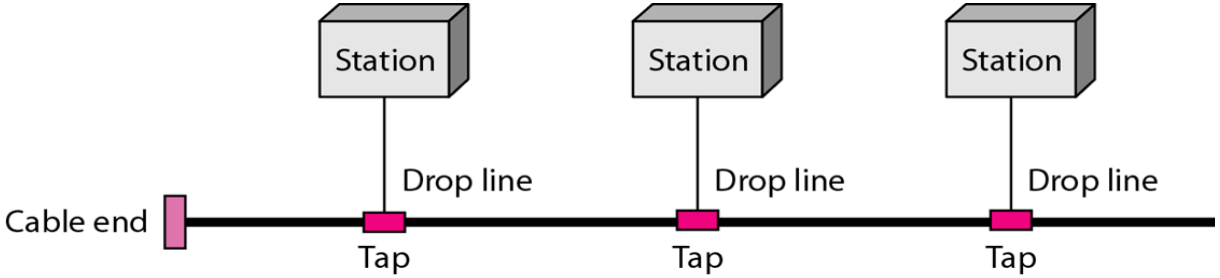
Physical Topology



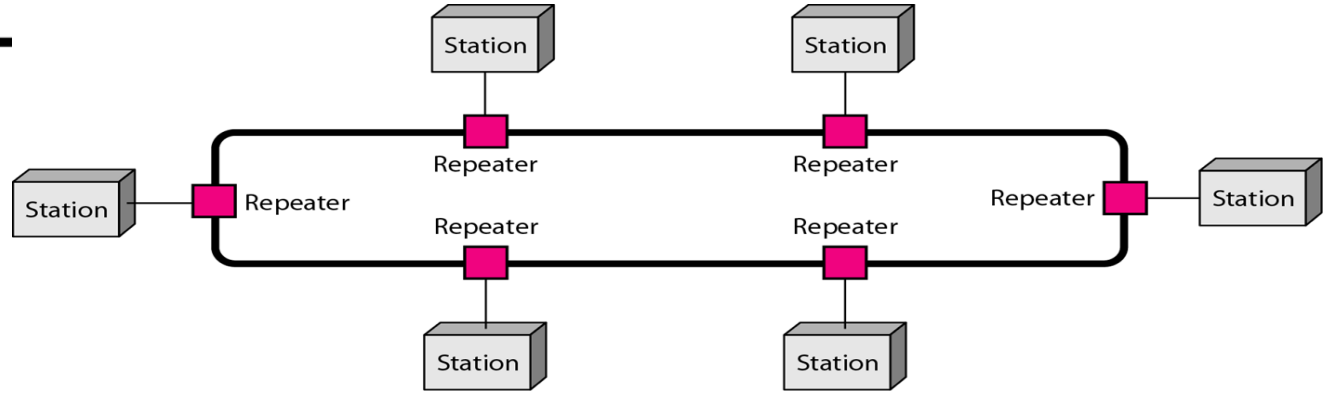
Mesh



Star

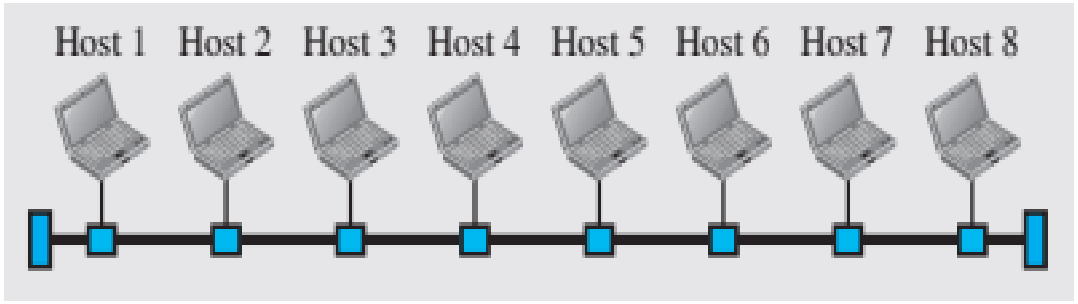


Bus

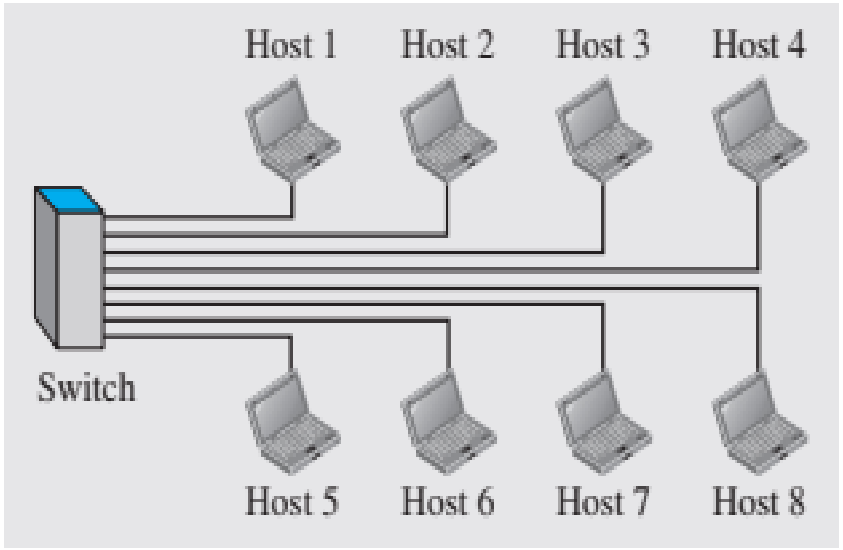


Ring

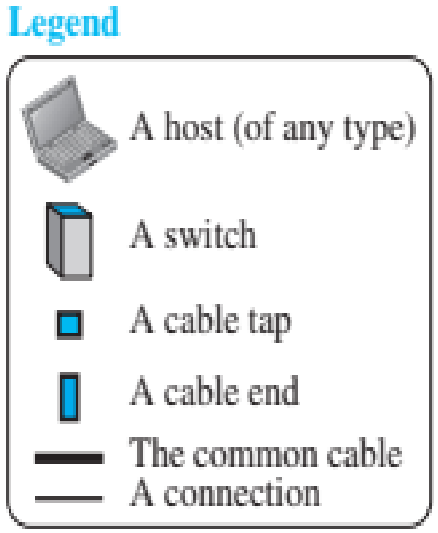
Network Types



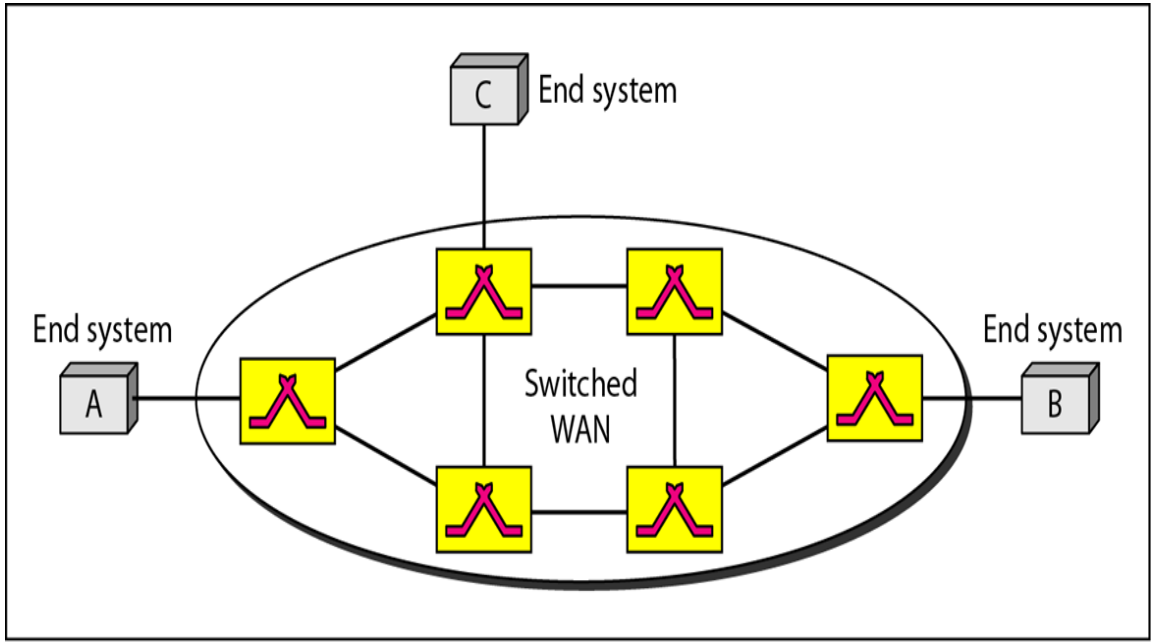
a. LAN with a common cable (past)



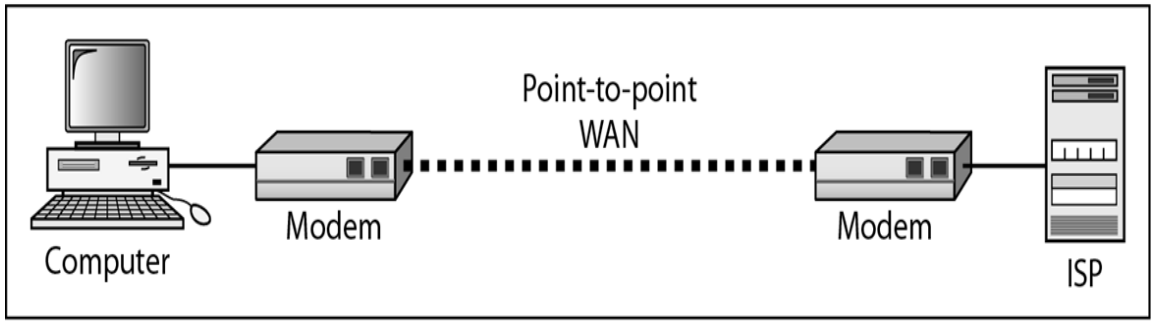
b. LAN with a switch (today)



Local Area Network (LAN)



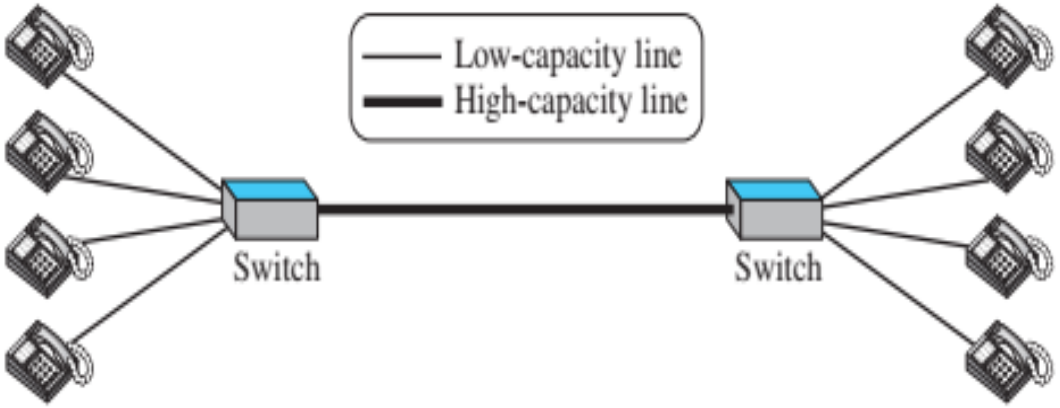
a. Switched WAN



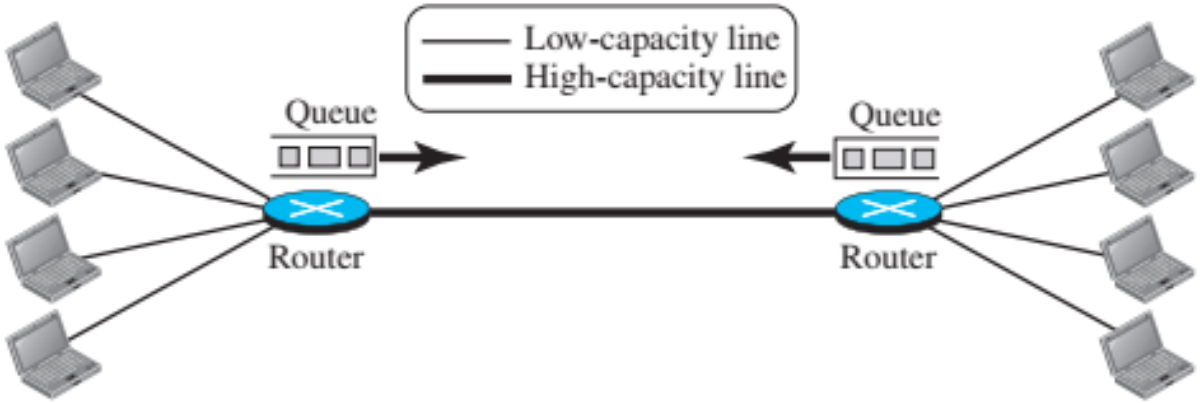
b. Point-to-point WAN

Wide Area Network (WAN)

Switching



Circuit-Switched Network

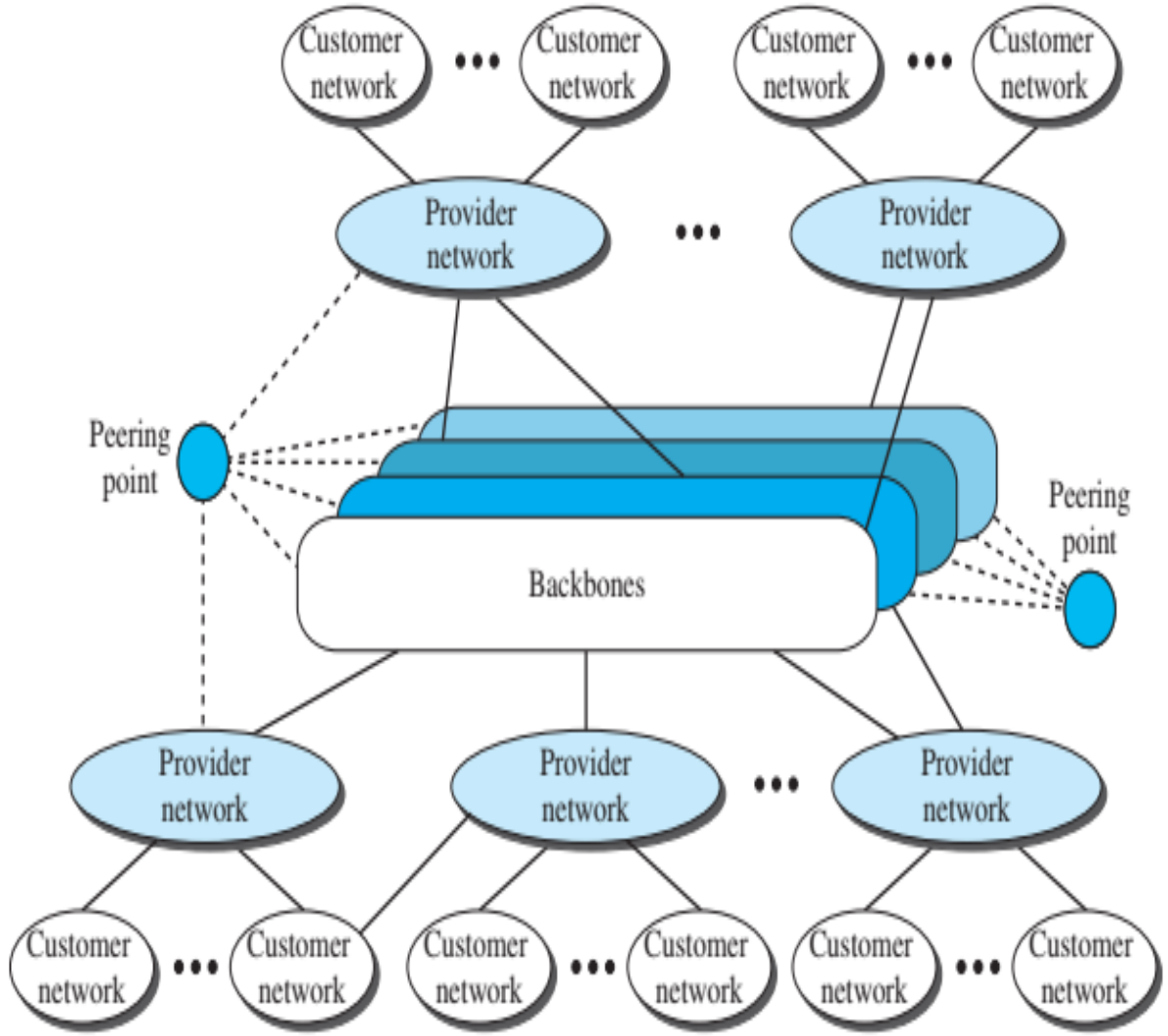


Packet-Switched Network

- Circuit-switched network
  - Dedicated connection (called a circuit) exists between two end systems
  - Switch makes it active or inactive; performs only forwarding tasks
  - Example: Telephone network
  - Limitation: high-capacity link remains under utilized majority of times
- Packet-switched network
  - Computers exchange *packets* (blocks of data) between one another
  - Switches have both forwarding and storing capabilities
  - Better utilization of the link capacity but introduces some delays

Present Day Internet

- A network is a group of connected, communicating devices.
- An internet is two or more networks that can communicate with each other.
- The most notable internet is called the Internet composed of thousands of interconnected networks.
- Three level hierarchical structure:
  - Backbones
  - Provider network
  - Customer network



Hierarchical Organization of the Internet

History of Internet

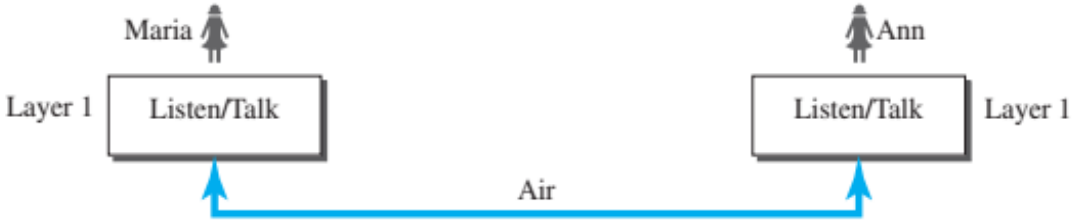
- Before 1960: telegraph & telephone networks
- 1961: Birth of packet-switched networks
- Mid-1960s: Defense Advanced Research Projects Agency (DoD)
- 1967: Advanced Research Projects Agency Network (ARPANET)
- 1969: Implementation of ARPANET
  - Four computers - *Interface Message Processor (IMP)*
  - *Network Control Protocol (NCP)* provided communication between hosts
- 1972: Internetting Project - Vint Cerf and Bob Kahn
  - Devised the idea of *gateway*
- 1973: Transmission Control Protocol (TCP) – new version of NCP
  - Landmark paper: outlined the protocol to achieve end-to-end communication
  - Concepts of encapsulation, datagram, function of gateway
- 1977: demonstration of an internet consisting of three different networks (ARPANET, packet radio, and packet satellite)
  - Split TCP: *Transmission Control Protocol (TCP)* and *Internetworking Protocol (IP)*

History of Internet (Contd…)

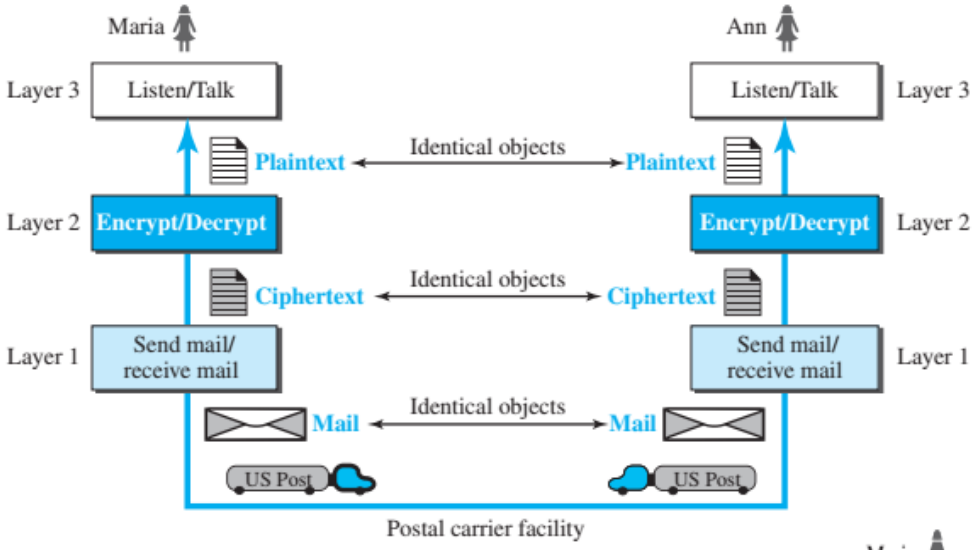
- 1981: UC Berkeley modified the UNIX operating system to include TCP/IP
  - Rise in the popularity of internetworking
  - Manufacturers used open-source Berkley UNIX code to build their products
- 1981: Creation of *Computer Science Network (CSNET)*
- 1983: ARPANET split into two networks: *Military Network (MILNET)* and *ARPANET*
  - TCP/IP became the official protocol for ARPANET
- 1986: Creation of *National Science Foundation Network (NSFNET)*
- 1991: Creation of a new, high-speed Internet backbone called *Advanced Network Services Network (ANSNET)*
  - Participating companies: IBM, Merit, Verizon
- 1990s: Emergence of the *World Wide Web (WWW)* – explosion of Internet!
  - The Web was invented at CERN by Tim Berners-Lee.
  - Three fundamental technologies: HTML, URI, HTTP
  - Added commercial application to the Internet

Protocol & Protocol Layering

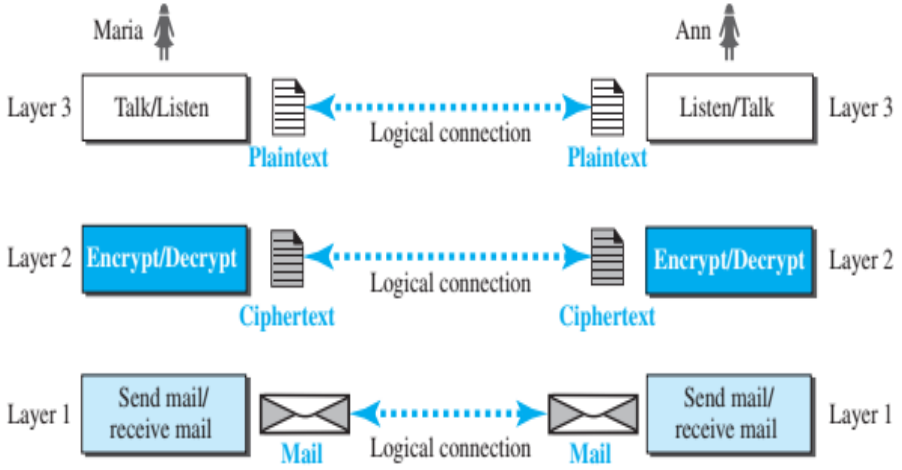
- It consists of a set of rules that govern data communications.
- To be followed by sender, receiver, and intermediate devices
- The key elements of a protocol are syntax, semantics and timing
- Advantages of protocol layering:
  - Divides complex communication task into several smaller and simpler tasks (modularity)
  - Decouples services from implementations
  - Simpler intermediate systems



Single Layer Protocol

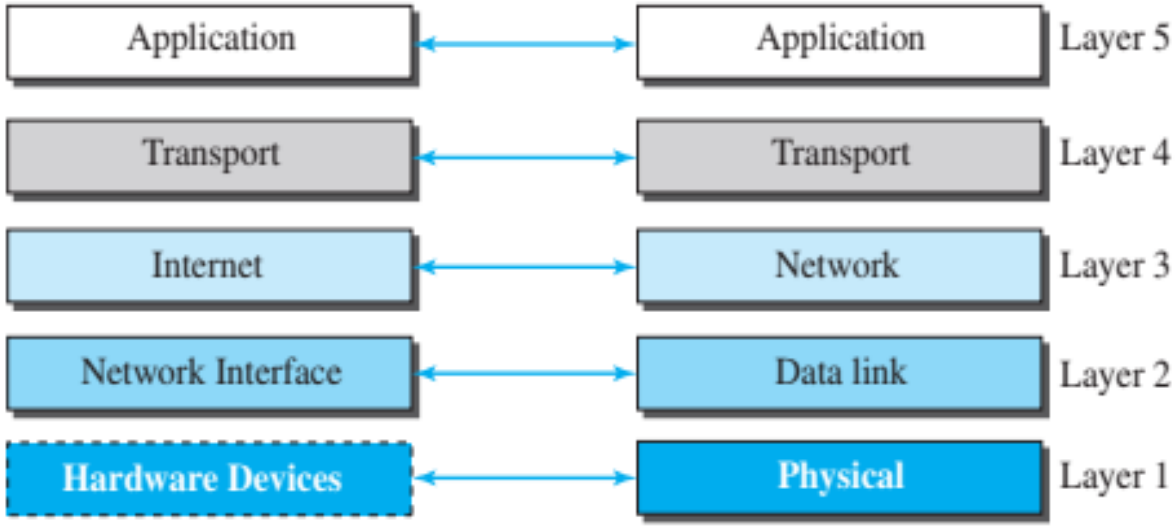


Three Layer Protocol

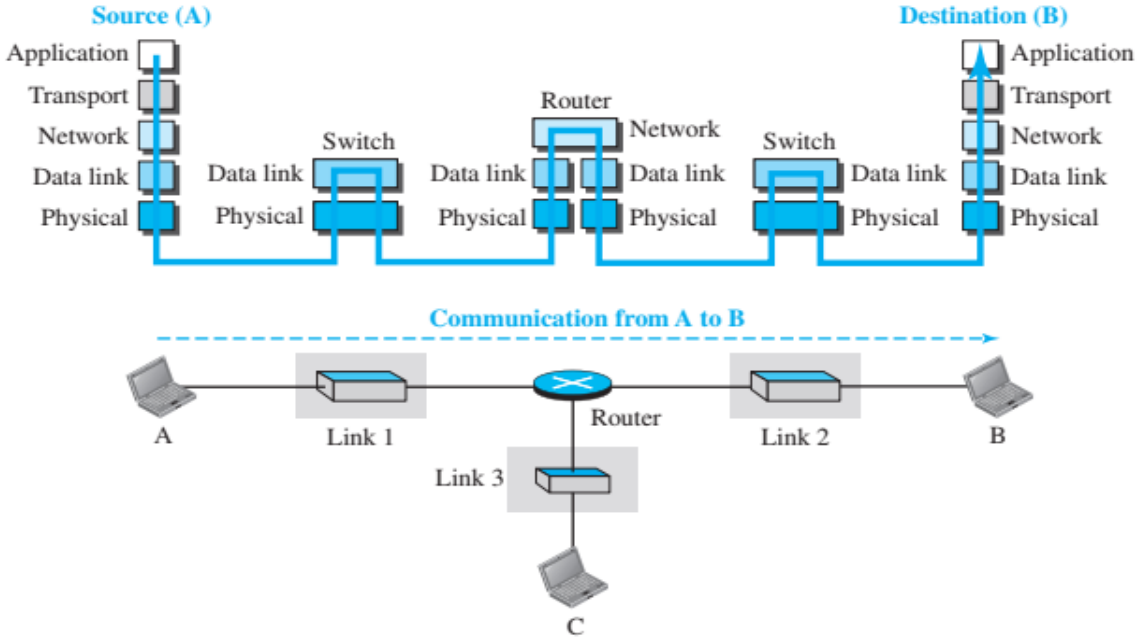


Logical Connection Between Peers

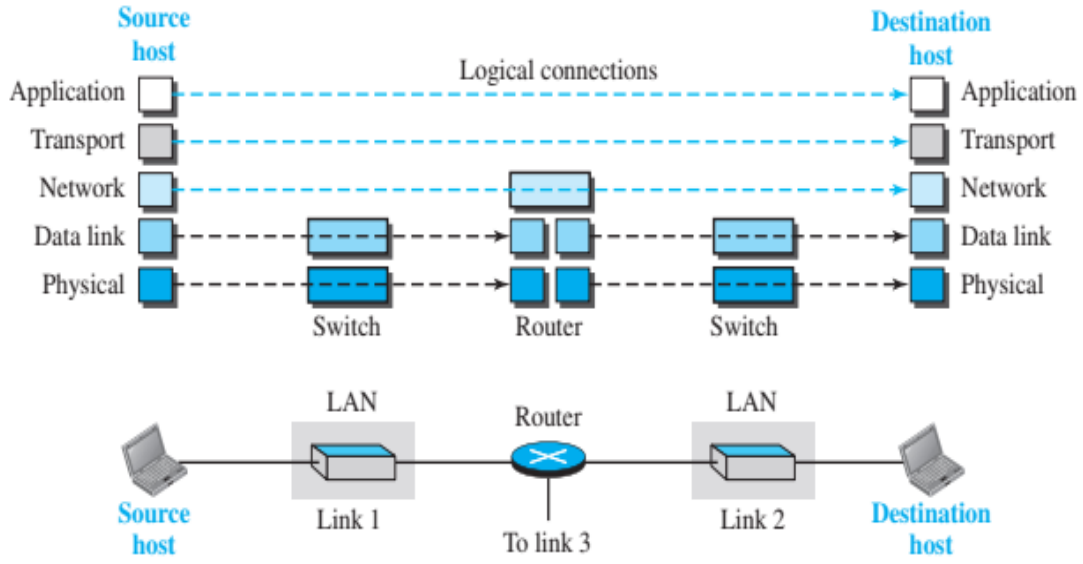
TCP/IP Protocol Suit



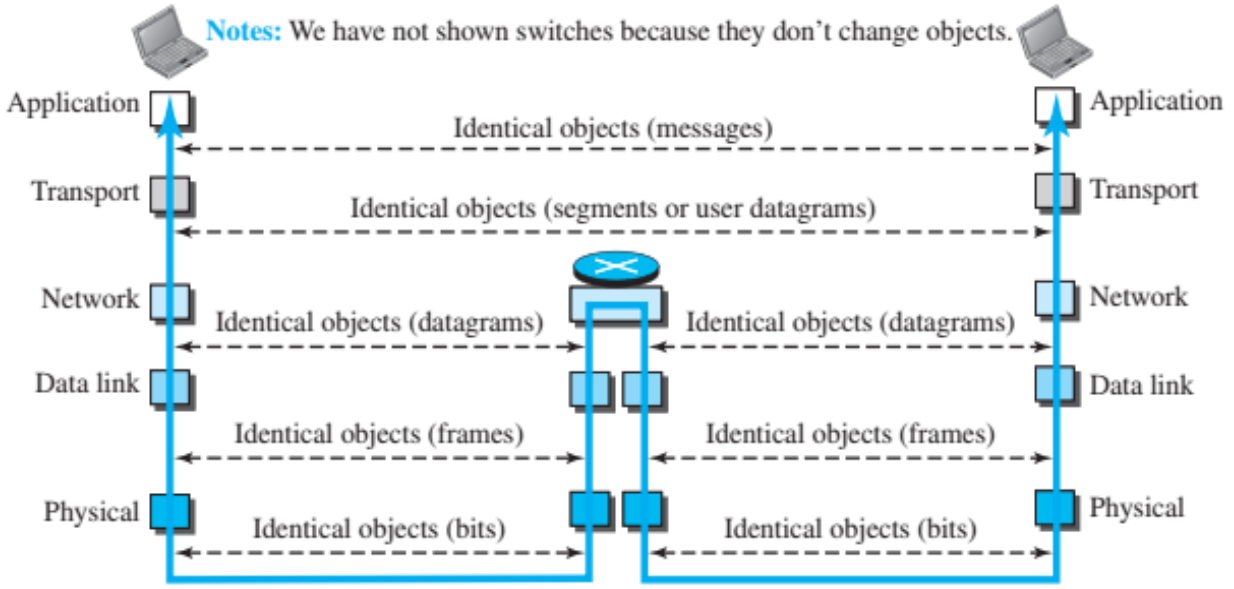
Original TCP/IP **Today's TCP/IP**



Communication through the internet



Logical Connection between TCP/IP Protocol Suite Layers



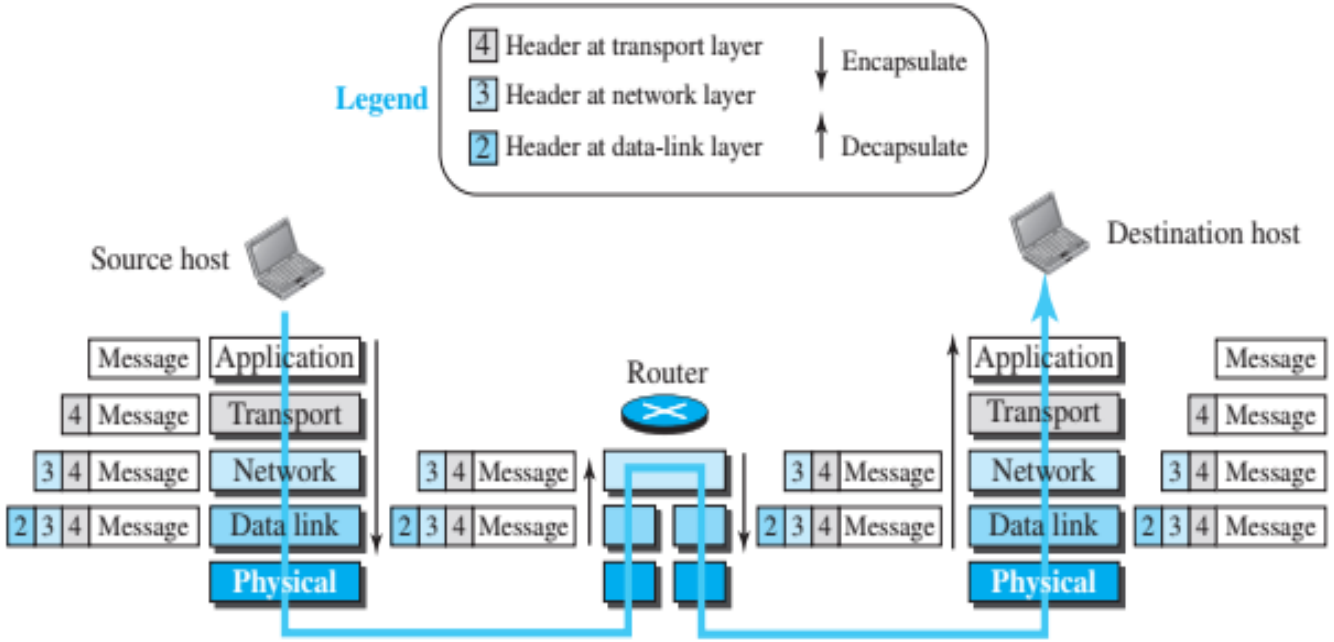
Identical Objects in the TCP/IP Protocol Suite

Description of Each Layer

Layers	Functionalities
Physical	• Carries individual bits in a frame across the link • Converts bits into electrical/optical signals so that they can be propagated through the transmission media (cable or air)
Data-Link	• Takes the datagram and carries it across the link as frame • Link can be either wired LAN with a link-layer switch, a wireless LAN, a wired WAN, or a wireless WAN. • May provide complete error detection and correction or only correction
Network	• Responsible for host-to-host communication • Chooses the best route for each packet • Internet Protocol (IP) defines the format of the packet (datagram), structure of the address used in the network layer • IP is responsible for routing a packet from source to destination, which is achieved by each router forwarding the datagram to the next router in its path • Other protocols in this layer: ICMP, IGMP, DHCP, ARP
Transport	• Responsible for process-to-process communication • Two main protocols: TCP (connection-oriented, reliable) & UDP (connection-less, unreliable) • Flow control, error control, congestion control
Application	• Process-to-process communication • Protocols supported by the application layer: HTTP, SMTP, FTP, TELNET, SSH, DNS, SNMP

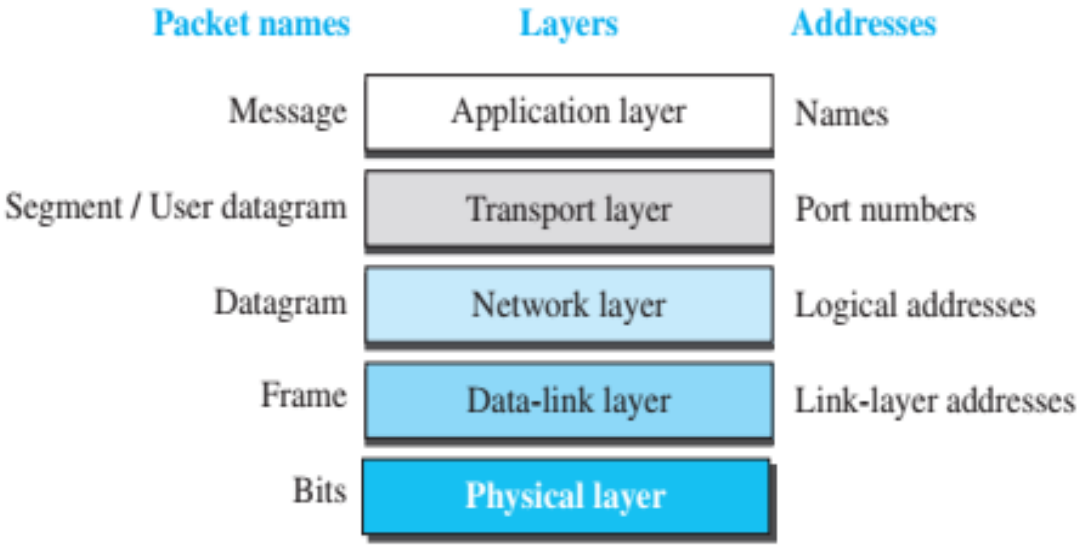
Two Important Concepts of Protocol Layering

- Encapsulation and Decapsulation



Encapsulation/Decapsulation

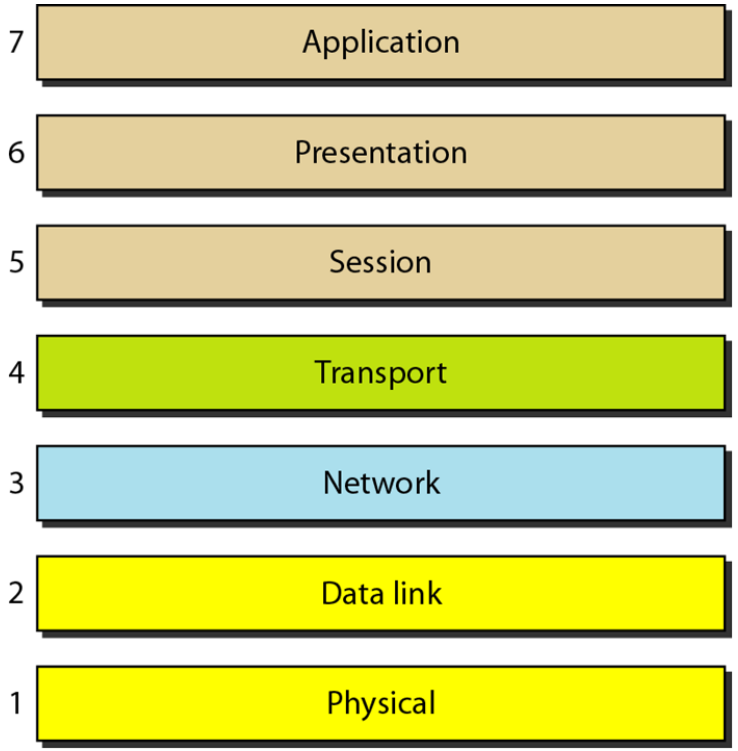
- Addressing



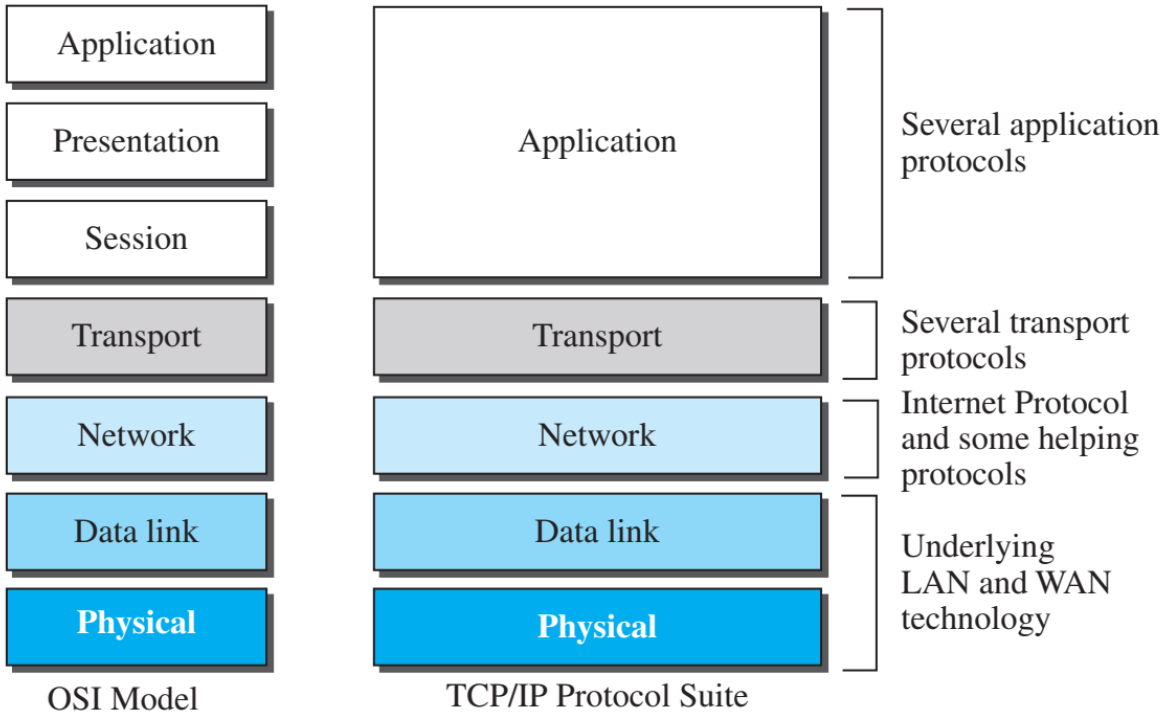
Addressing in the TCP/IP Protocol Suite

The OSI Model

- International Organization for Standardization (ISO)
  - multinational body dedicated to worldwide agreement on international standards.
- Open Systems Interconnection (OSI) model
  - An ISO standard that covers all aspects of network communication



OSI Model



OSI Model vs. TCP/IP Protocol Suite