DATA COMMUNICATIONS

Data Communications

- **Communication** involves information sharing : local or remote

- **Telecommunication** – communication at a distance
  - *tele*phony, *tele*graphy, *tele*vision

- **Data communications** – the exchange of *data* between devices via some form of transmission medium such as wire cable
  - **data** - information presented in whatever form agreed upon by parties creating and using data

- Devices must be part of a **data communications system (DCS)** , a combination of hardware and software

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Effective DCS

- ## Delivery
  - Must deliver data to the correct destination

- ## Accuracy
  - Must deliver data accurately

- ## Timeliness
  - Must deliver data in a timely manner

- ## Jitter
  - Must consider variations in the packet arrival time

Components of a DCS (1)

- **Message**
  - Information to be communicated

- **Sender**
  - Device that sends the message: computer, phone

- **Receiver**
  - Device that receives the message: computer, phone

- **Transmission Medium**
  - Physical path by which a message travels from sender to receiver: twisted-pair wire, coaxial cable, fiber optics, radio waves

- **Protocol**
  - A set of rules that govern data communications
  - An agreement between the communicating devices

Components of a DCS (2)
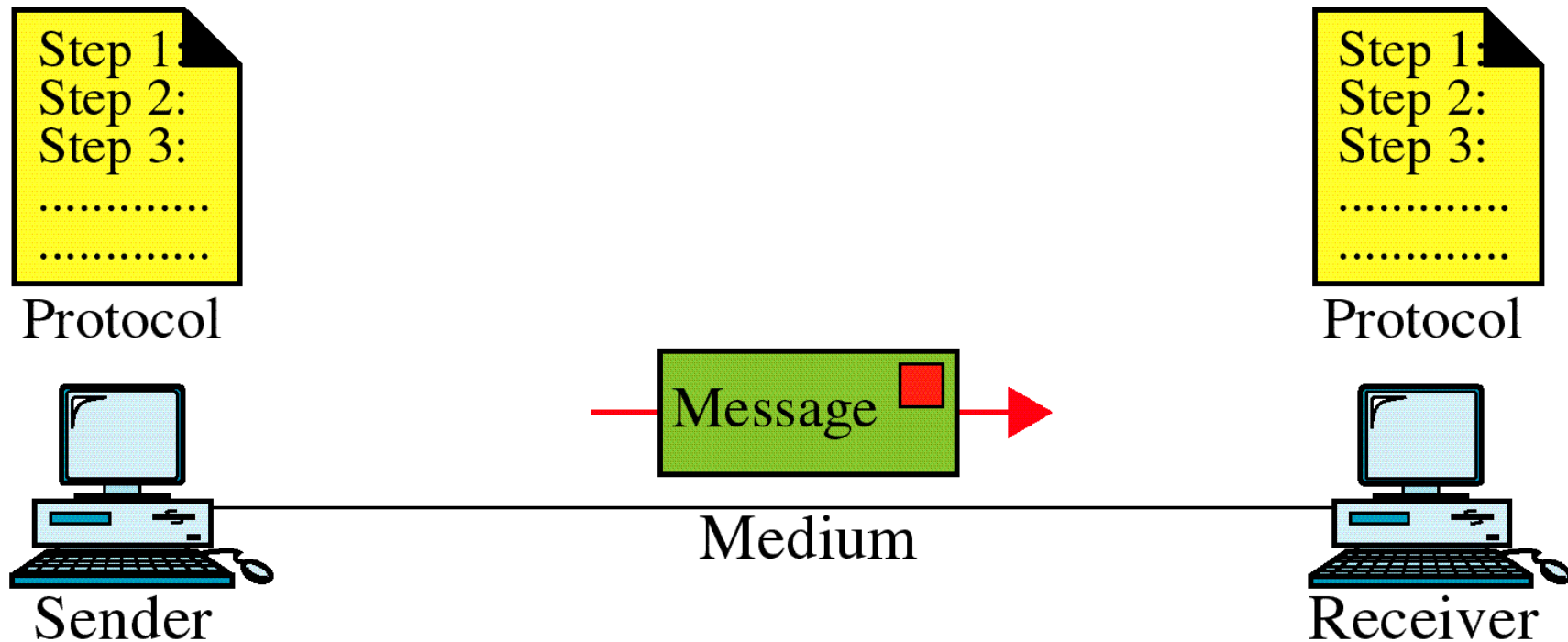
Data Representation (1)

- Text

  - Bit pattern, sequence of 0's and 1's

  - Code/Character Set - a set of bit patterns used to represent text symbols

  - Unicode – uses 32 bits to represent a symbol or character used in any language in the world

  - American Standard Code for Information Interchange (ASCII) – uses 8 bits

  - ex. U+0041 represents the Latin Capital letter 'A'

Data Representation (2)

- ## Numbers

  - represented as bit patterns but is directly converted to a binary number

  - ex. the number 2 is represented as 00000010

- ## Images

  - Bit patterns represented as a matrix of pixels

  - CMSC 165!

Data Representation (3)

- ## Audio
  - Recording or broadcasting of sound or music
  - Represented by a continuous signal

- ## Video
  - Recording or broadcasting of a picture or movie
  - Continuous, via TV Camera
  - Discrete, combination of images (frames)

Data Flow

- ## Simplex
  - Only one side can transmit, unidirectional, can use the entire capacity of the channel
  - ex. keyboards, monitors

- ## Half-duplex
  - Both sides can transmit but one at a time, channel capacity is taken over by whichever side is transmitting
  - Ex. Walkie-talkie and CB(citizens band) radio

- ## Full-duplex/Duplex
  - Both sides can send and receive simultaneously
  - Channel is shared: two physical links or channel capacity is divided
  - ex. telephone network

NETWORKS

What is a network?

- A set of devices (nodes) connected by communication links

- Uses distributed processing
  - A task is divided among multiple computers

Network Criteria (1)

- Performance

  - Transmit time – amount of time required for a message to travel from one device to another

  - Response time – elapsed time between an inquiry and a response

  - Depends on the *number of users*, *type of transmission medium*, *capabilities of connected hardware*, *efficiency of software*

  - Ideal metrics: More throughput, less delay

Network Criteria (2)

- ## Reliability

  - Measured by the <u>frequency of failure</u>, <u>the time it takes a link to recover from a failure</u>, and the network's <u>robustness in a catastrophe</u>

- ## Security

  - <u>Protecting data from unauthorized access</u>, <u>protecting data from damage</u>, <u>implementing policies and procedures for recovery from breaches and data losses</u>

Network Criteria (3)
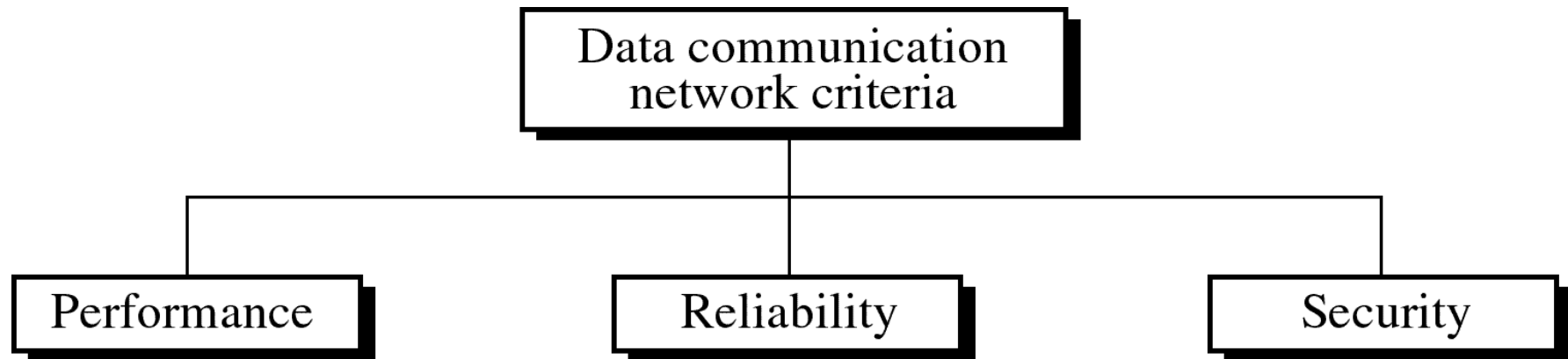
Physical Structures: Type of Connection (1)

- ## Point-to-Point

  - Provides a dedicated link between to devices, usually through a wire/cable

  - Channel capacity is reserved for the two devices

  - ex. TV remote control (uses infrared)

- ## Multipoint/multidrop

  - More than two specific devices share a single link
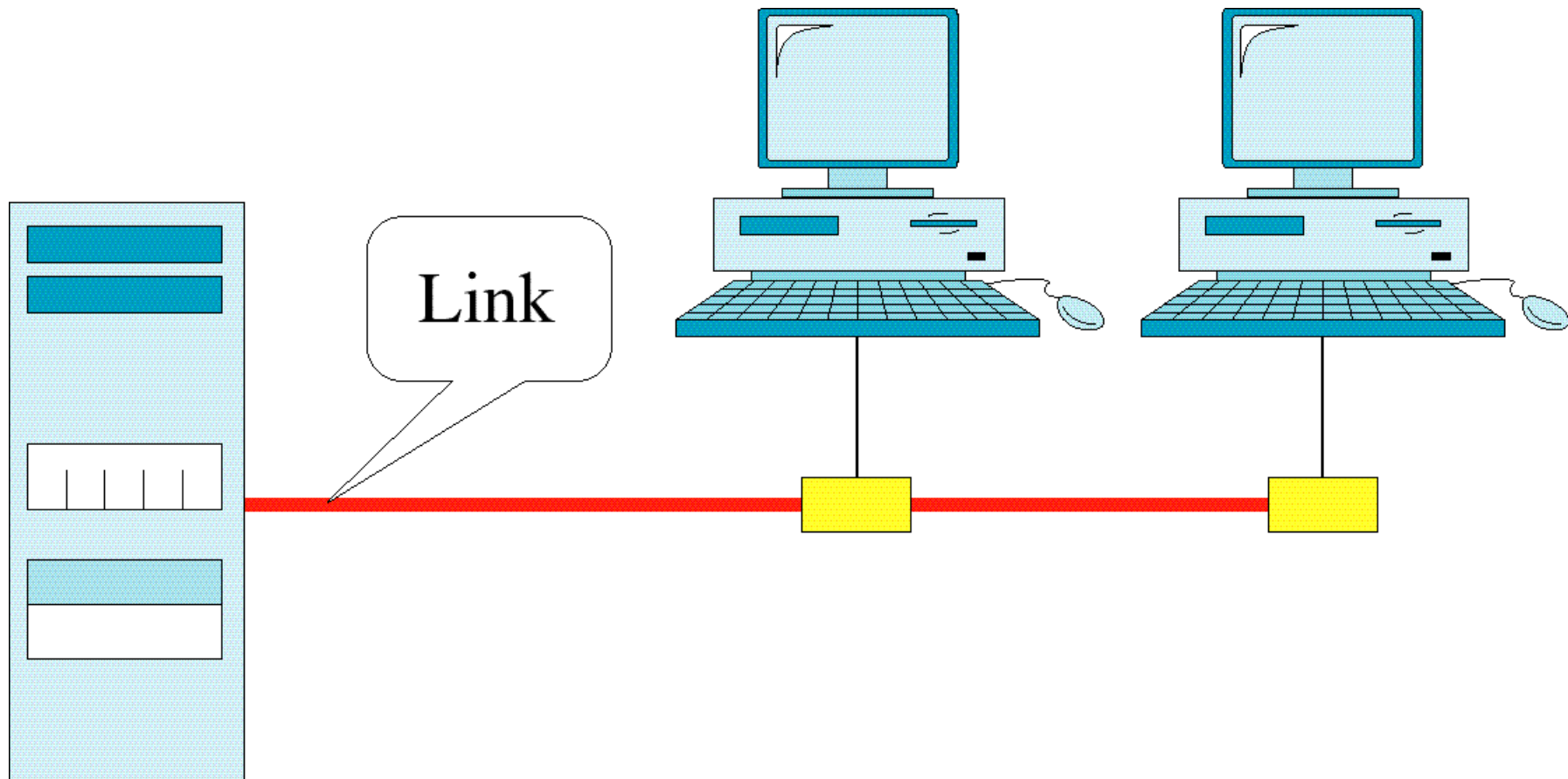
  - Channel capacity is shared, spatially or temporally

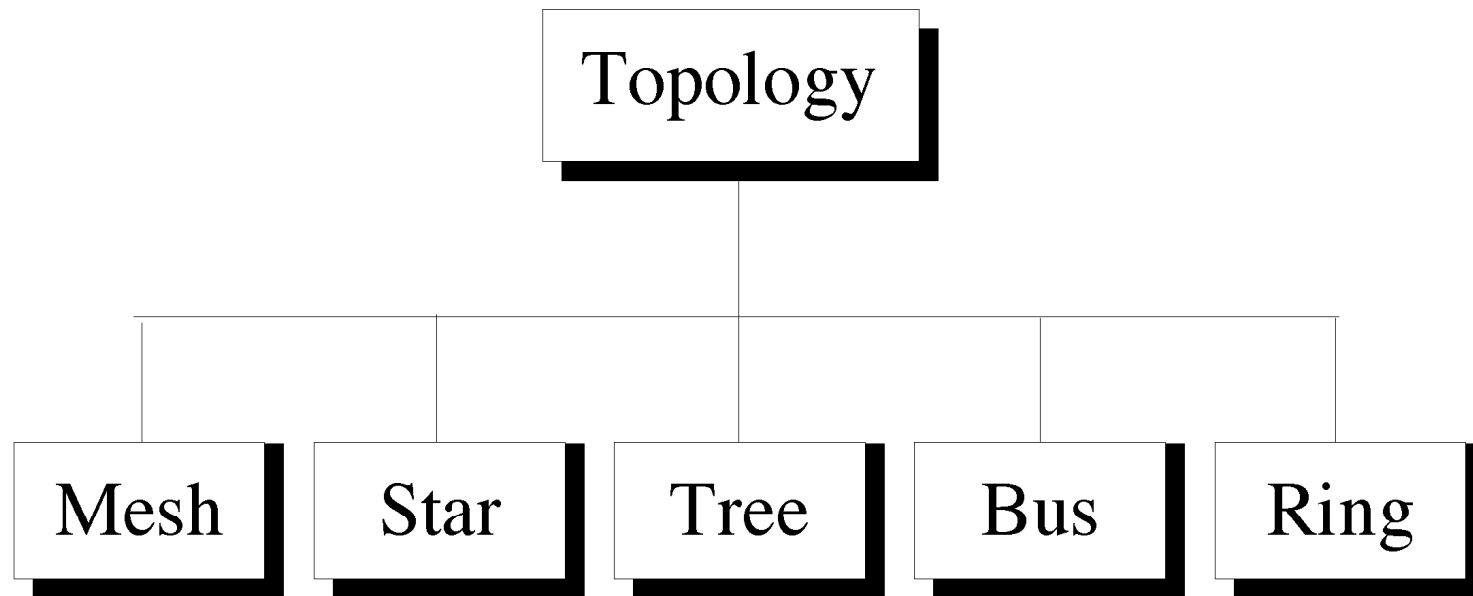# Physical Structures: Type of Connection (2)

- Point-to-Point
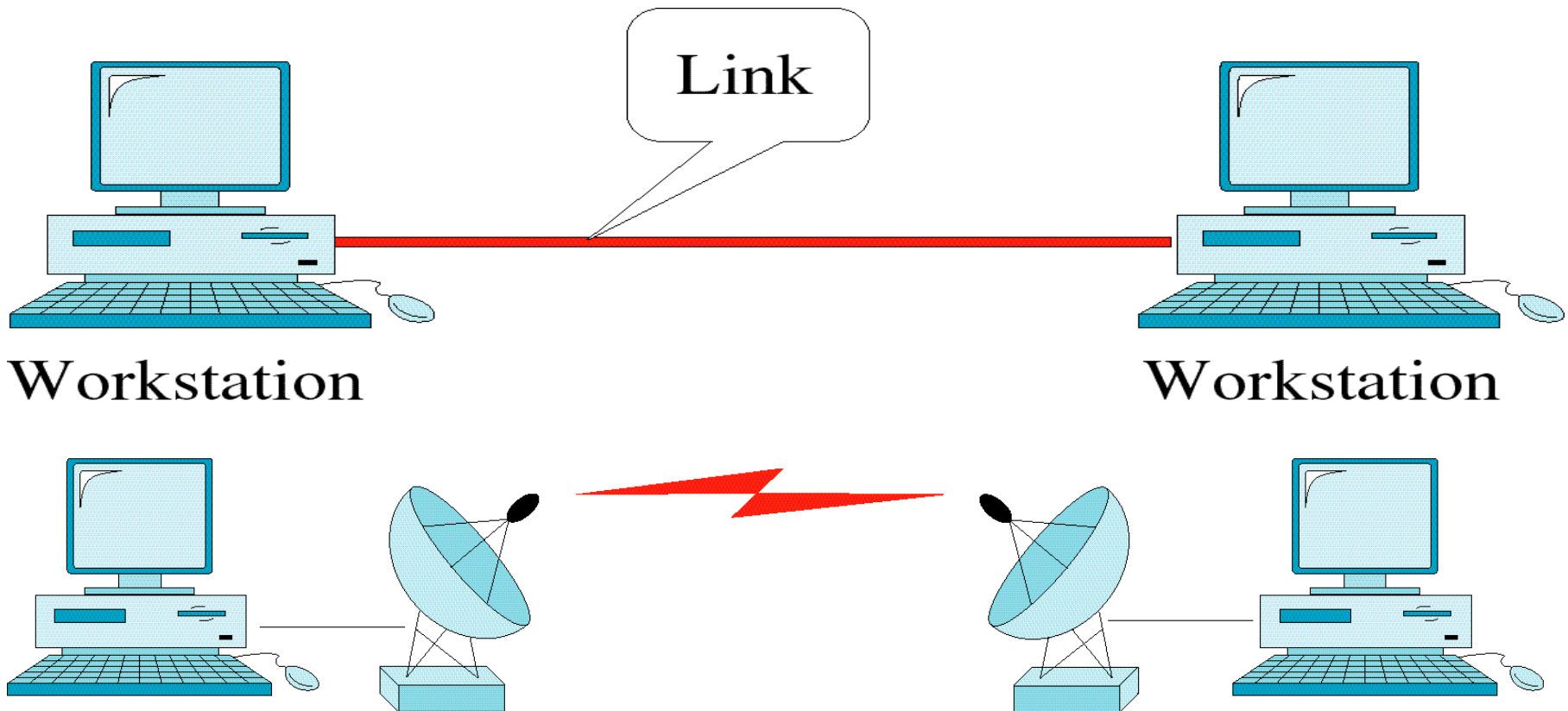
Physical Structures: Type of Connection (3)

- Multipoint

Link

Physical Structures: Topology

- Refers to the way in which a network is laid out physically

- Geometric representation of the relationship of all the links and nodes to one another

Topology: Mesh (1)

- Every device has a dedicated point-to-point link to every other device
- Number of duplex-mode links: n(n-1)/2
- How many I/O ports are needed?
- Advantages
  - No link sharing, robust, privacy and security, makes fault isolation easy
- Disadvantages
  - High cost
- ex. Regional telephone connections

Topology: Mesh (2)
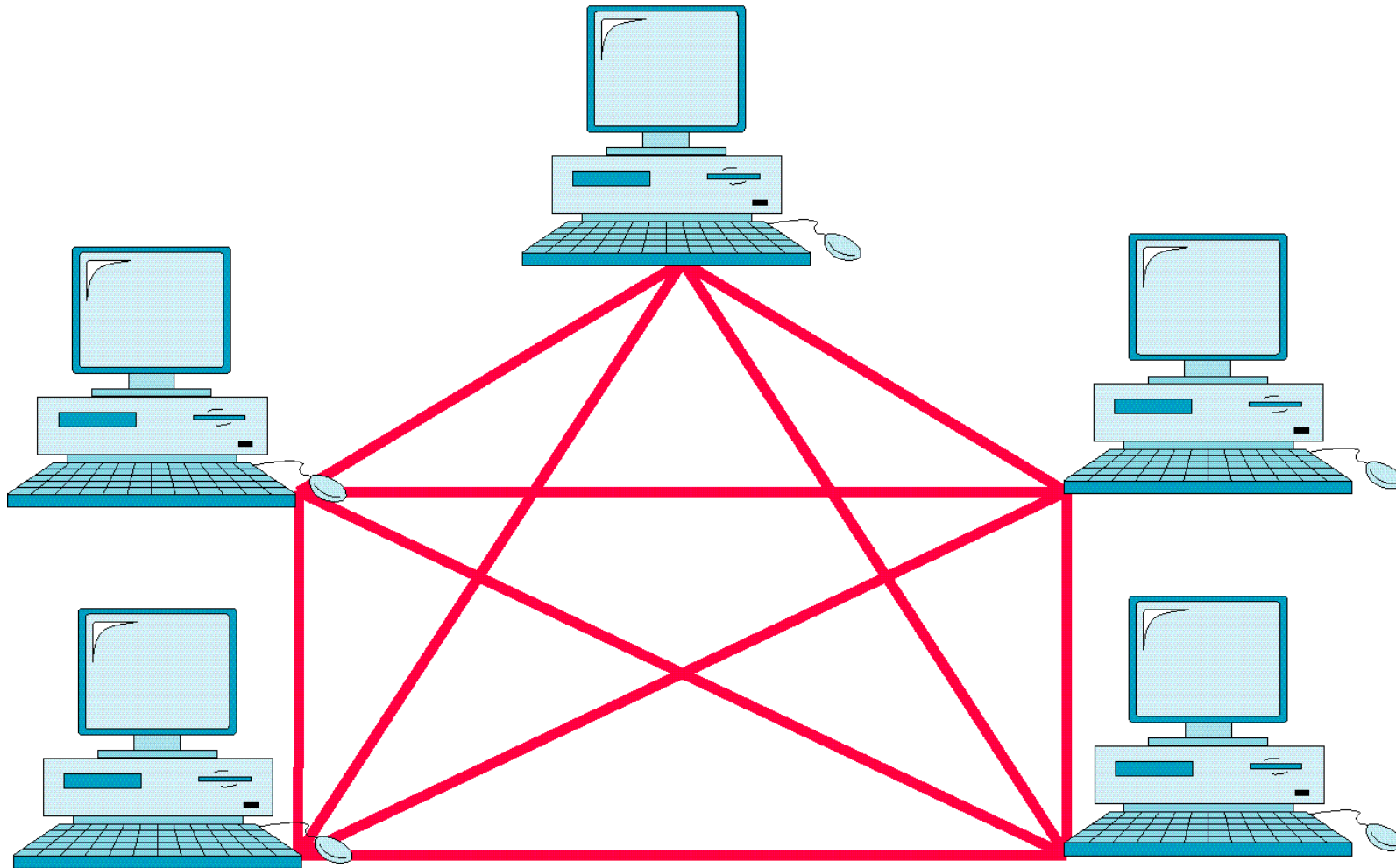
Topology: Star (1)

- Has a dedicated point-to-point link only to a central controller called a hub

- No direct traffic between devices, controller relays traffic

- Advantages

    - Cheaper than mesh, easy to install and reconfigure, robustness

- Disadvantages

   - Hub is the single point of failure, sometimes more cabling is required

Topology: Star (2)
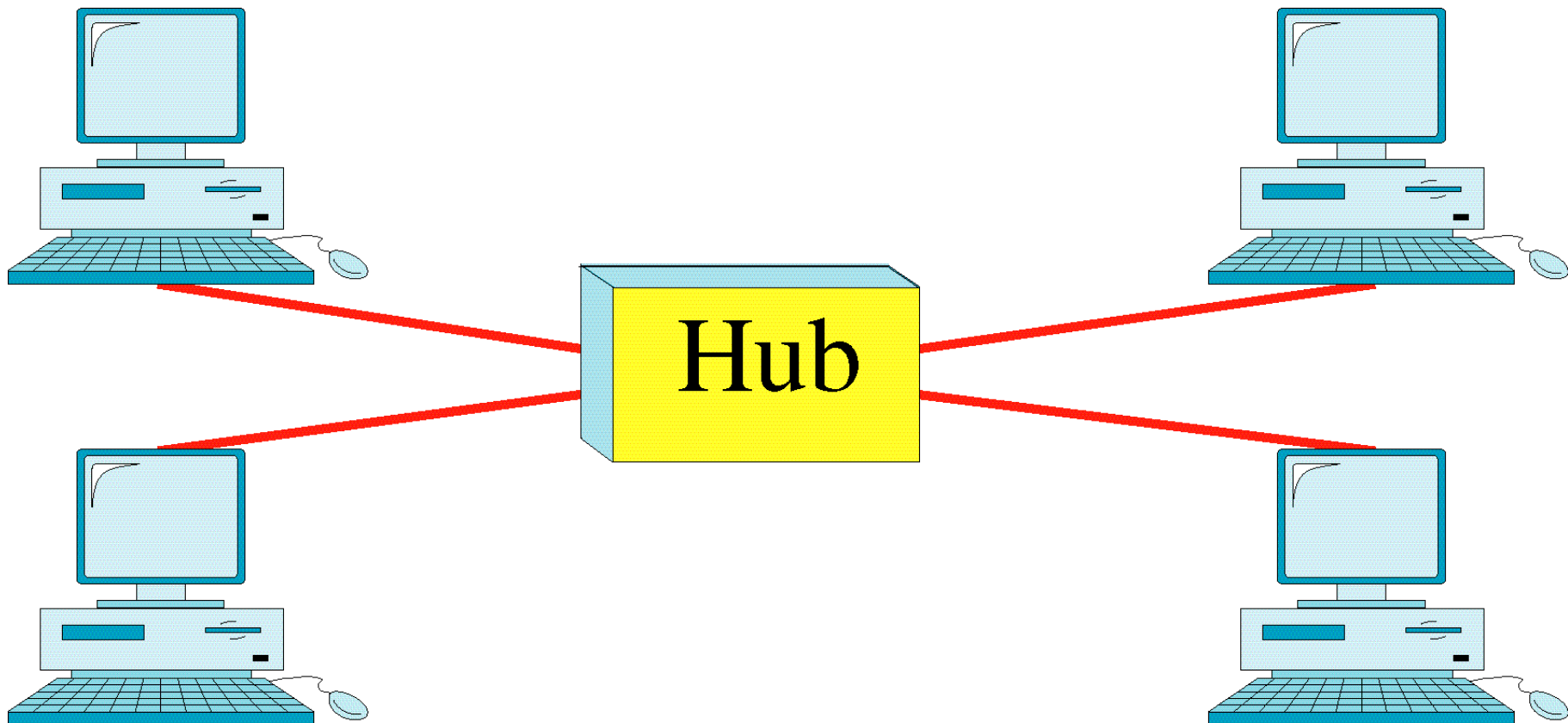
Topology: Bus (1)

- Uses multipoint connection

- Backbone cable links all devices in the network

- Connection is via drop lines and taps

- Advantages

  - Ease of installation

- Disadvantages

  - Difficult reconnection and fault isolation, reduced quality because of signal reflection in taps, single break in backbone stops all transmission

Topology: Bus (2)
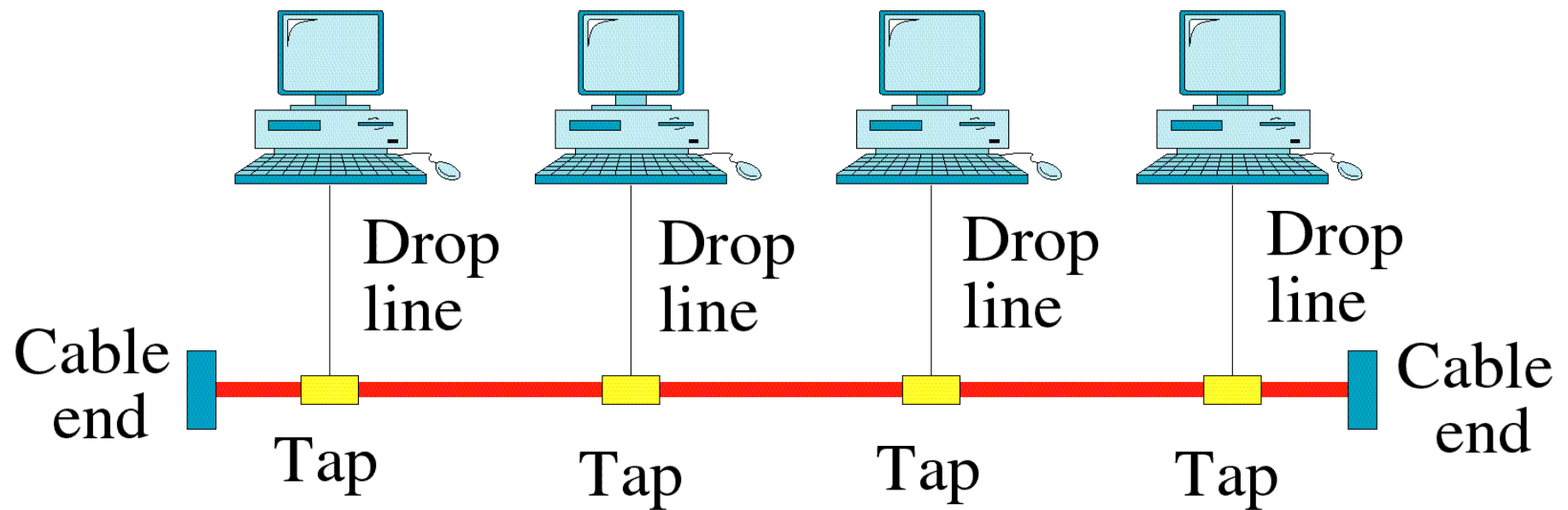
Topology: Ring (1)

- Each device has a dedicated point-to-point link with only two devices on either side of it

- Signal passed along the ring in one direction, from device to device, until it reaches its destination

- Repeaters regenerate the signal intended for another device

- Advantages: easy to install and configure, simplified fault isolation

- Disadvantages: a break in the ring can disable the network (solved by using a dual ring)

Topology: Ring (2)
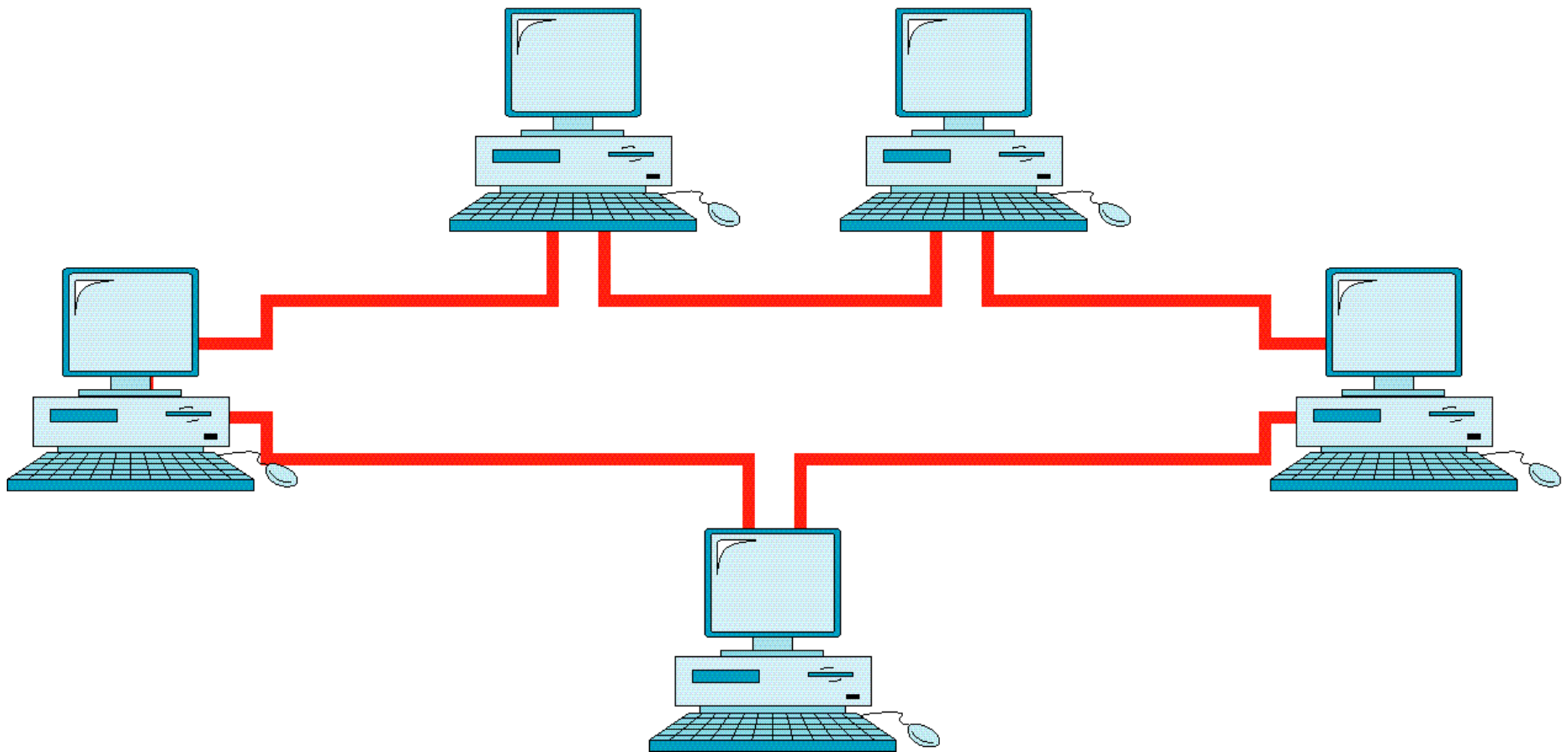
Topology: Hybrid (1)
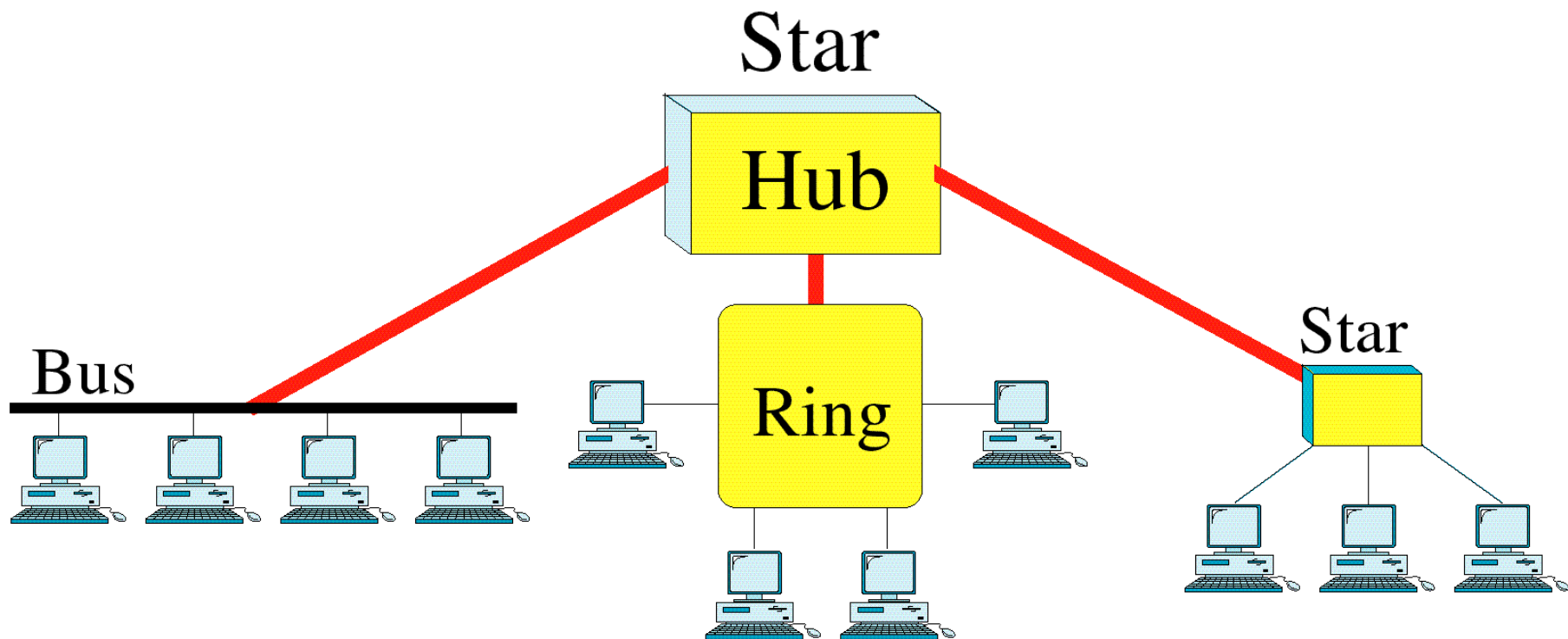
Network Models

- Allows heterogeneous networks created by different entities to communicate

- OSI (Open Systems Interconnection) model defines a seven-layer network

- Internet model defines a five-layer network
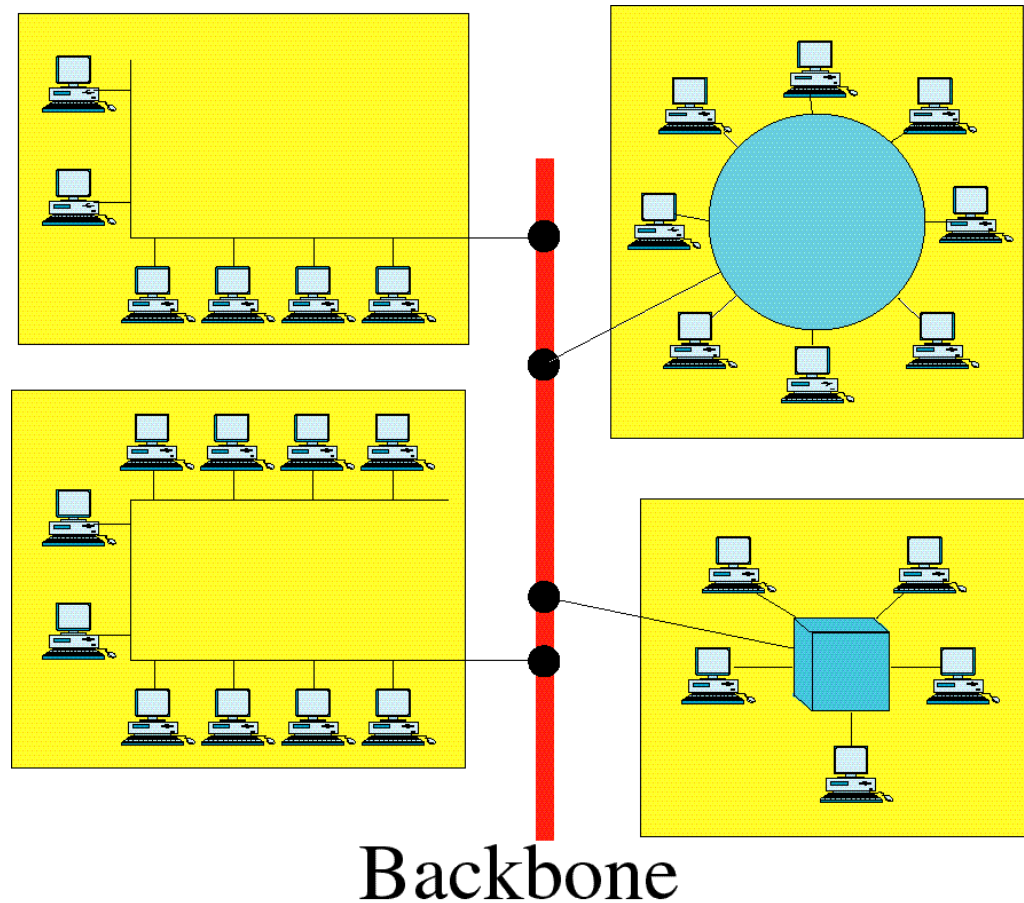
Categories of Networks: LAN (1)

- Local Area Networks (LAN)

- Privately owned

- Can be as simple as two PCs and a printer

- Found in business environments: resource sharing (hardware or software)

- Limited to a few kilometers

- Also defined by transmission media and topology (bus, ring, star)

- Typical data rates: 100 Mbps or 1000 Mbps

- WLANs becoming popular

Categories of Networks: LAN (2)
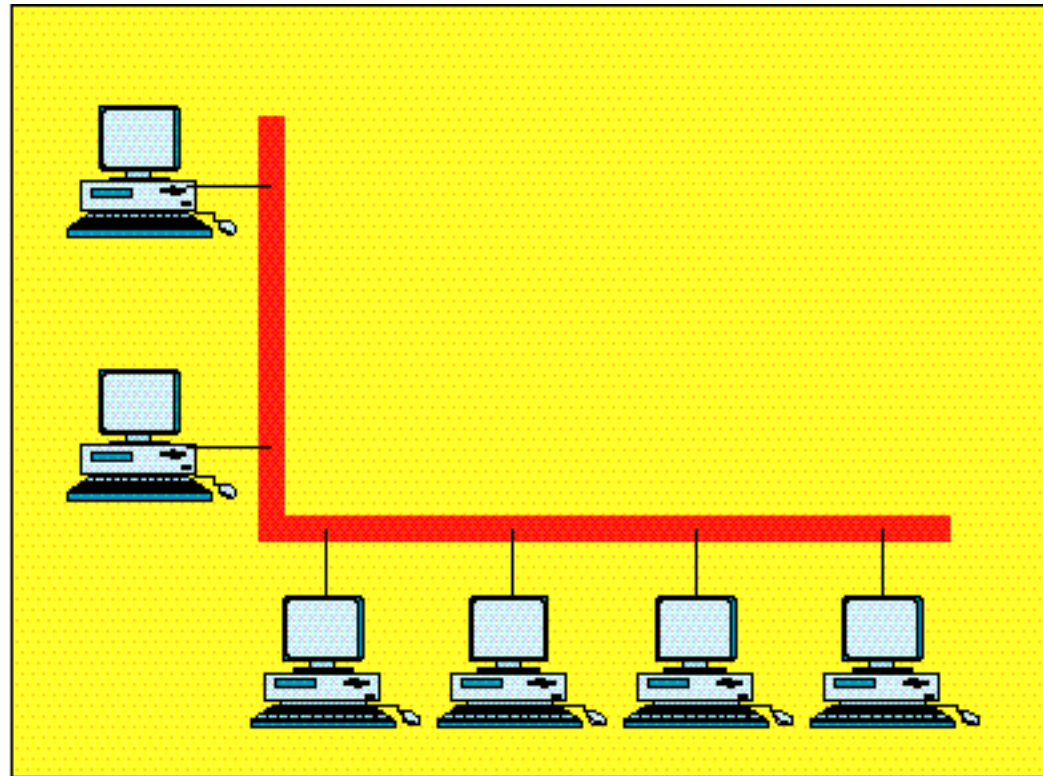
Single building LAN

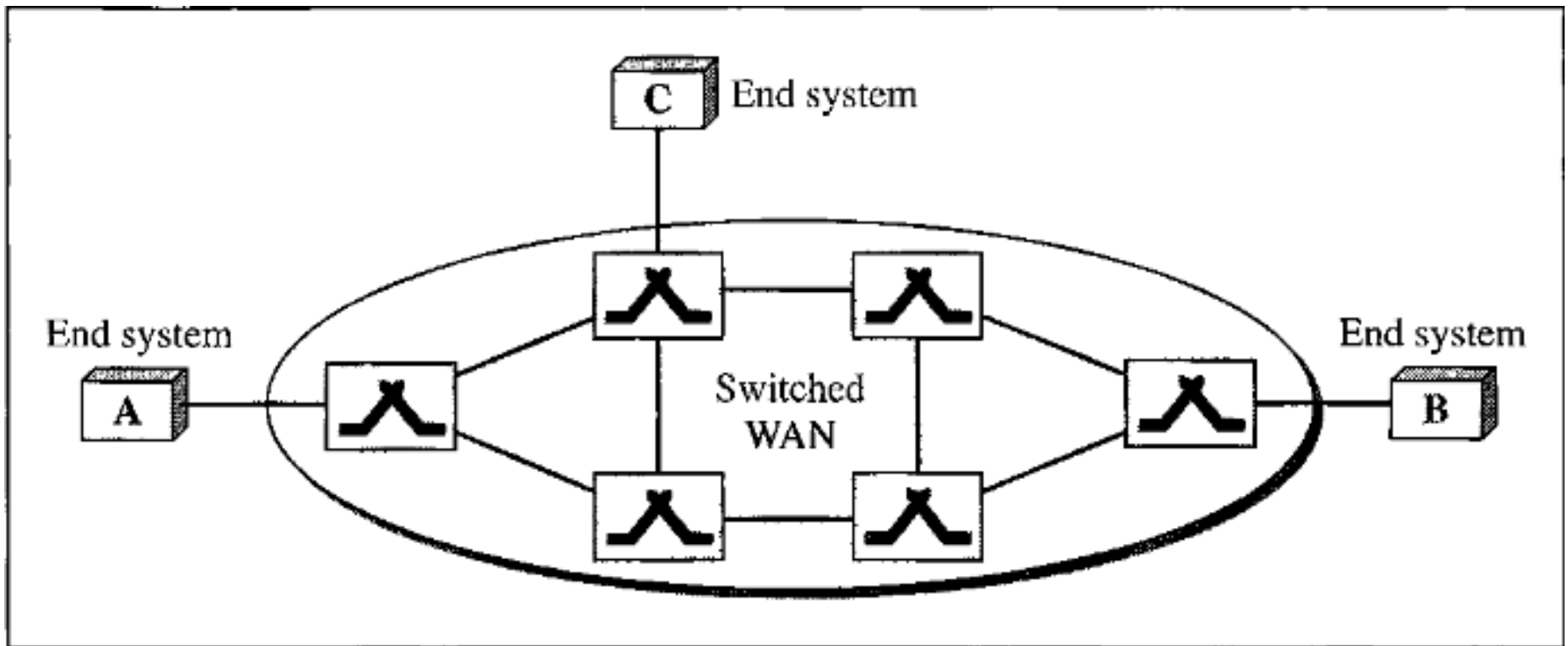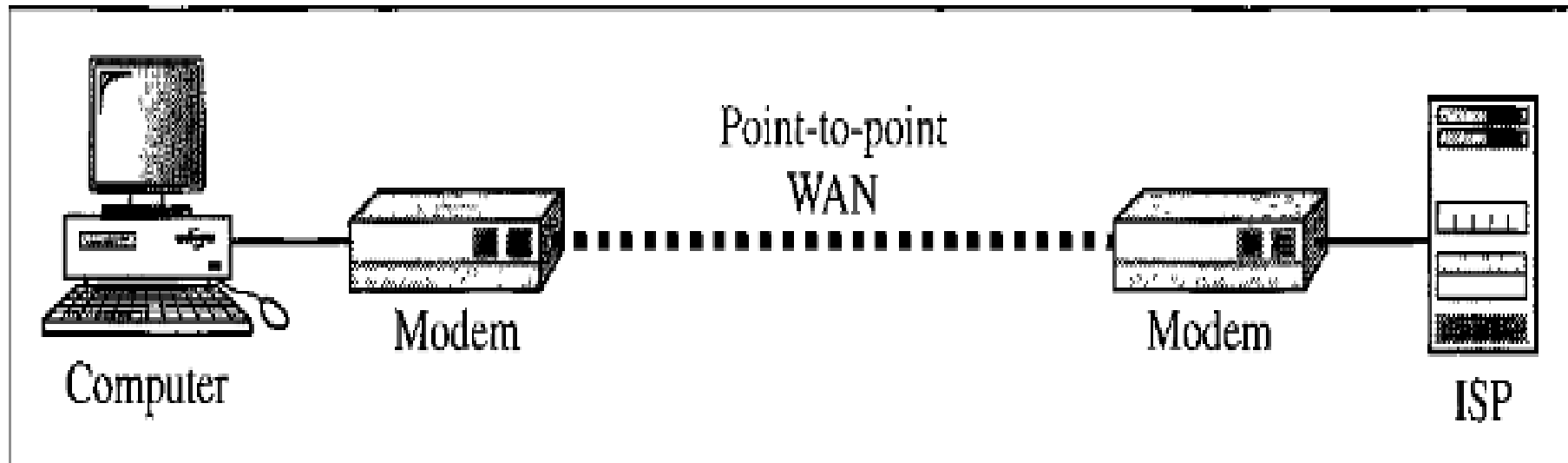# Categories of Networks: LAN (3)

Backbone

Multiple building LAN

Categories of Networks: WAN (1)

- Wide Area Networks (WAN)

- Long distance transmission of data

- ex. Internet backbone(switched WAN) or dial-up line (point-to-point WAN)

- X.25, ATM, WWAN

Categories of Networks: WAN (2)

Categories of Networks: WAN (3)

Point-to-point WAN

Computer — Modem .... Modem — ISP
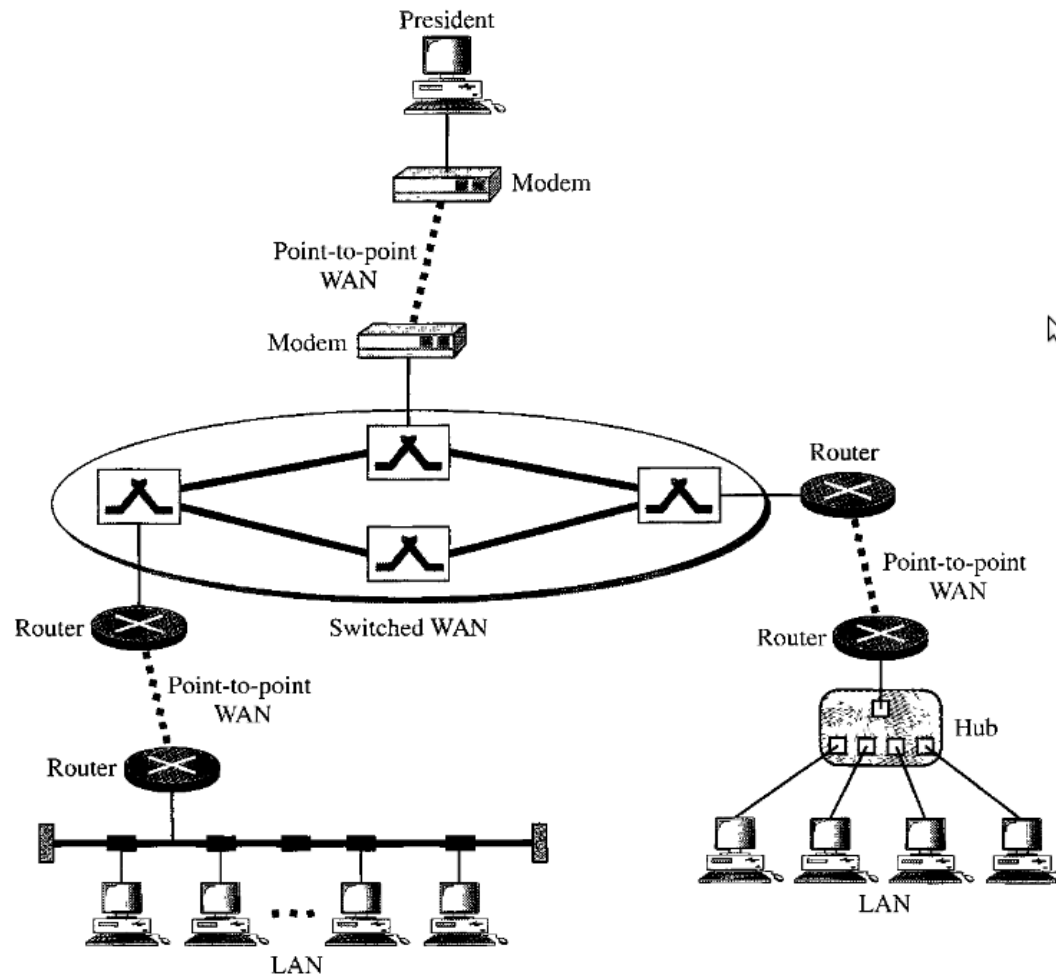
Categories of Networks: MAN

- Metropolitan Area Network (MAN)

- Size between LAN and MAN

- Town or city installation

- ex. DSL, Cable Internet

Interconnection of Networks:Internetwork

THE INTERNET

The Internet: History (1)

- **i**nternet – two or more networks that can communicate with each other

- **I**nternet – collaboration of more than thousands of interconnected networks

- **Mid-1960's** – computers are standalone

- **A**dvanced **R**esearch **P**rojects **A**gency was interested in finding a way to connect computers to reduce cost and eliminate duplication of efforts

- **1967** – ACM presented ARPANET, small network of computers which used **I**nteface **M**essage **P**rocessors

- UCLA, UCSB, SRI, and UU connected via software called **N**etwork **C**ontrol **P**rotocol

The Internet: History (2)

- **1972** – Vint Cerf and Bob Kahn worked on the **Internetting Project**

- **1973** – paper outlining the protocols to achieve end-to-end delivery of packets, called **Transmission Control Protocol**

- Original TCP was split into two: TCP and IP

- **TCP/IP** became known as the internetworking protocol

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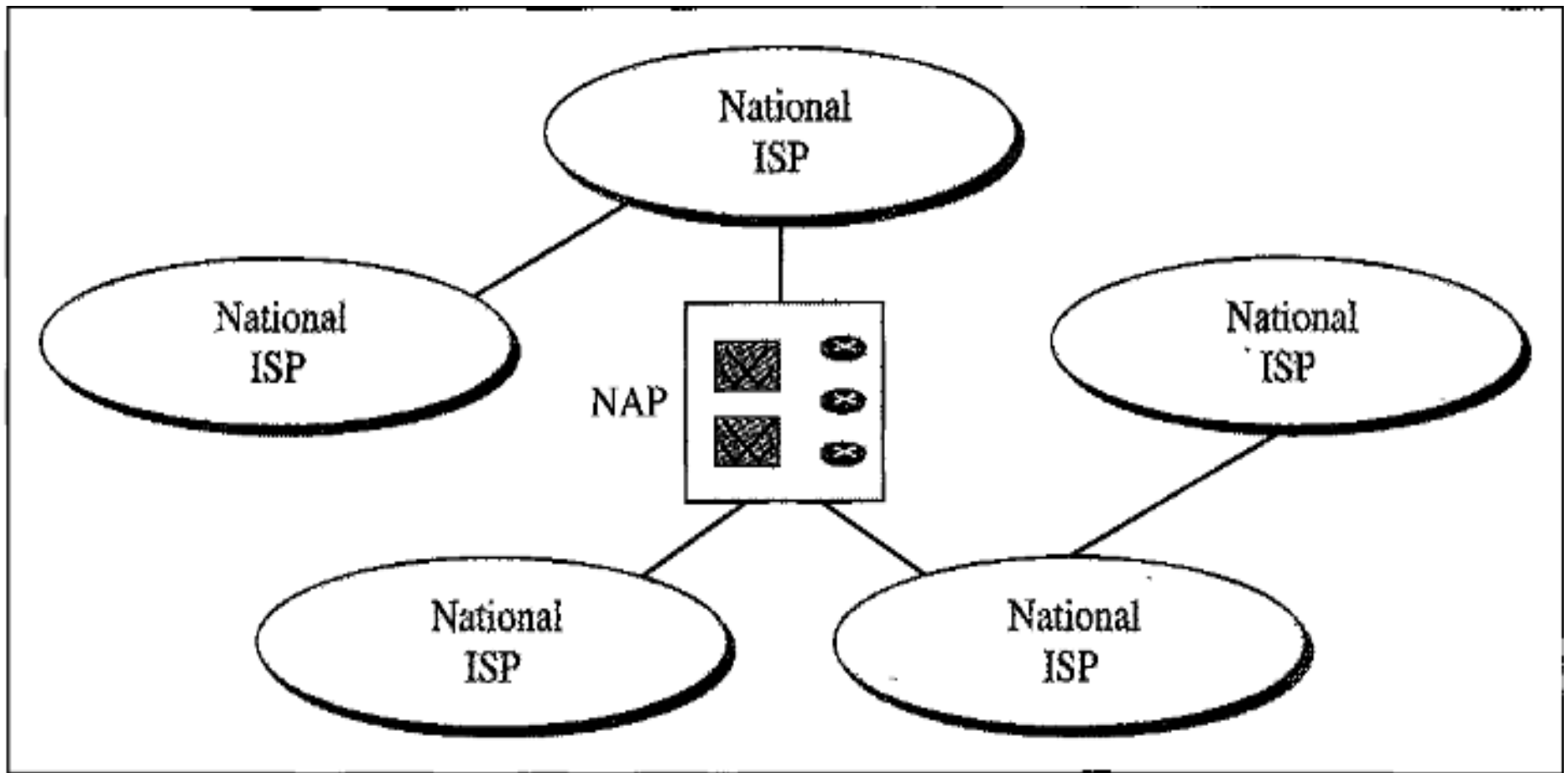Data Communications and Networking
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The Internet: Today (1)

- Made up of many wide- and local-area networks joined by connecting devices and switching stations

- Internet Service Providers provide Internet access to users

- International ISP, National ISP, Regional ISP, Local ISP

The Internet: Today (2)
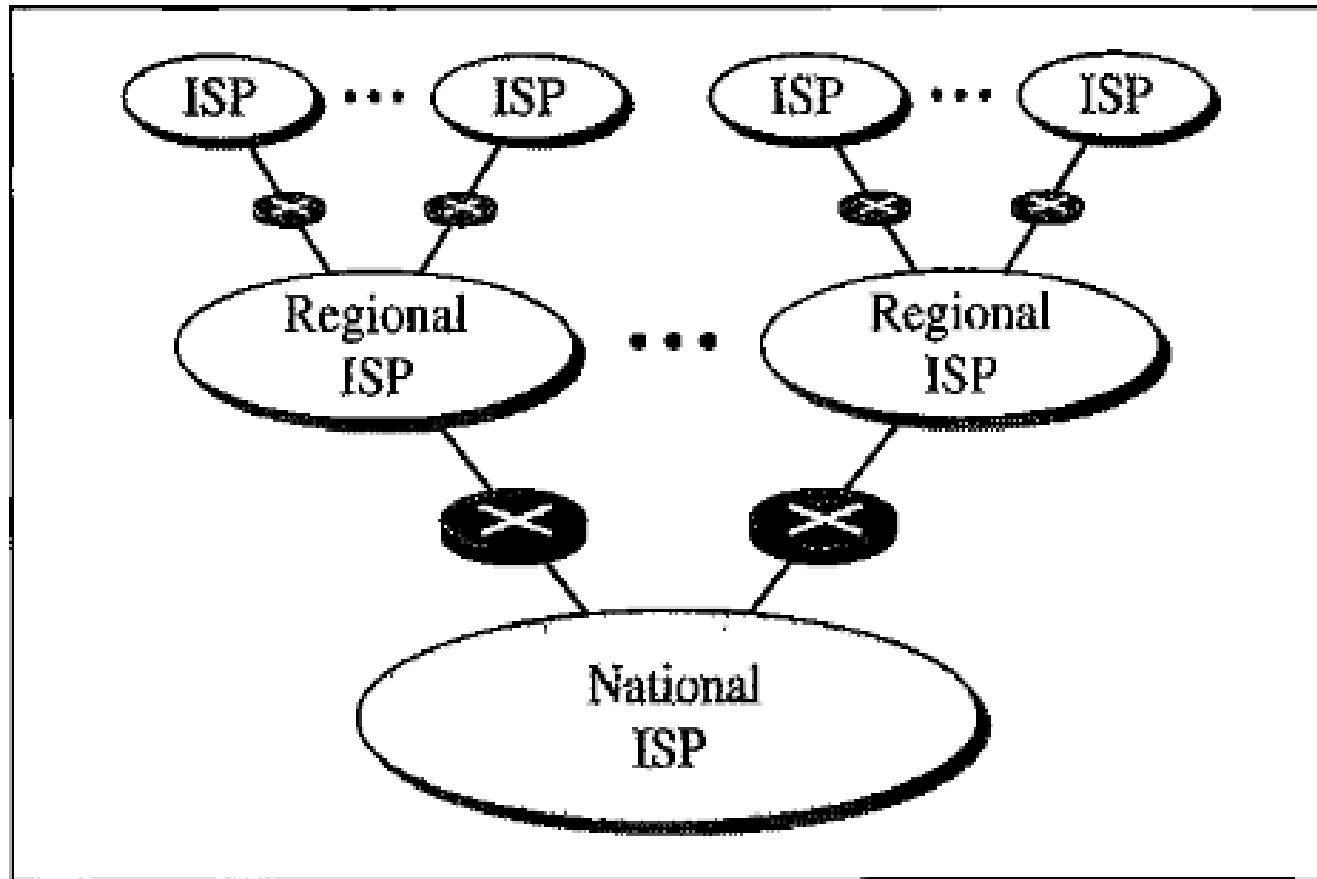
The Internet: Today (3)

PROTOCOLS AND STANDARDS

Protocols

- Communication occurs between entities in different systems

- Entity – anything capable of sending or receiving information

- A protocol is a set of rules that govern data communications

  - What is communicated, how it is communicated, when it is communicated

Elements of a protocol

- Syntax – structure and format of data

- Semantics – meaning and of each section of bits

- Timing – *when data should be sent* and *how fast they can be sent*

Standards

- Creates and maintains an open and competitive market for manufacturers

- Guarantees national and international operability of data and telecommunications technology and processes

- De facto("by fact") – have not been approved by an organized body but have been adopted as standards through widespread use

- De jure("by law") – have been legislated by an officially recognized body

How are standards developed?

- **Standard creation committees** – ISO, ITU-T, CCITT, ANSI, IEEE
  - Slow approval process
- **Forums** – speeds up acceptance and use of technology
  - Conclusions presented in standards bodies
- **Government regulatory agencies**
  - FCC
  - To protect public interest

Internet Standards

- A throughly tested specification that is useful to and adhered to by those who work with the Internet

- Specification begins as an Internet draft
  - Work-in-progress, 6-month lifetime

- Upon recommendation, may be published as **R**equest **f**or **C**omment
  - Edited, assigned a number, made available to interested parties

Enjoy! :)