Chapter 1

The Internet Introduced

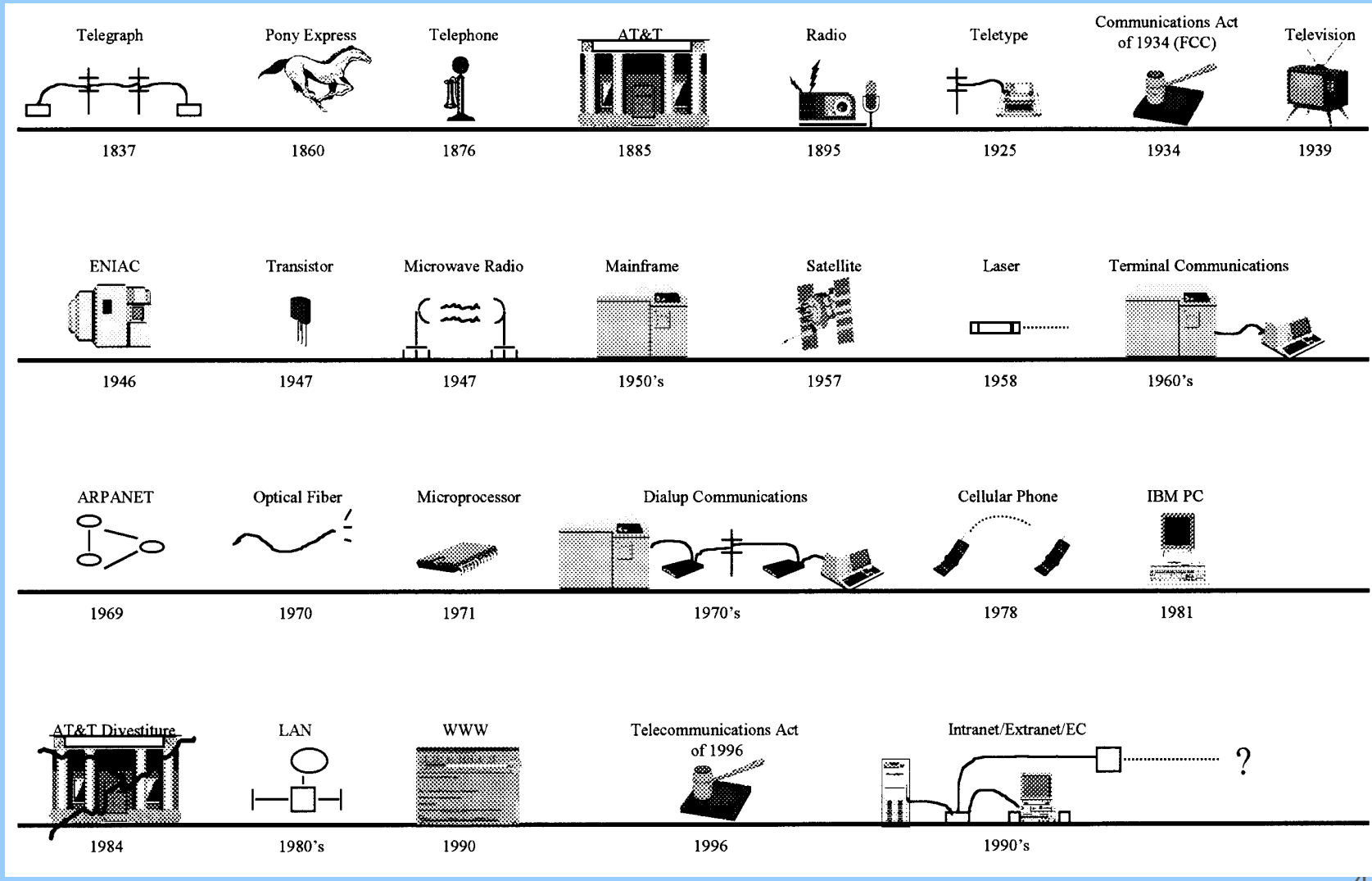
Telecommunications

- The transmission and reception of encoded information between two or more “intelligent” entities over an appreciable distance using an agreed-upon protocol

Telecommunication Requirements

- Language
- Medium for *electronic* transmission
  - Air, wire, fiber
- Protocol (rules)
- Transmitter & receiver
- Noise/Interference
- Intelligence

Telecommunications Timeline



Key Telecom Events

- 1847 - Telegraph
- 1877 - Telephone
- 1885 - American Telephone and Telegraph Company (AT&T) formed
- 1895 - Radio
- 1934 - Communications Act of 1934 (FCC)
- 1939 - Television
- 1947 - Microwave communications
- 1956 - First transatlantic telephone cable TAT-1
- 1957 - Satellite
- 1960s Computer/Terminal communications

Key Telecom Events

- 1969 - ARPANET
  - An experimental data network
- 1970 - Fiber optics
- 1970s - Dial-up computer communications
- 1978 - Cellular phone
- 1981 - IBM PC
- 1984 - AT&T Divestiture
- 1980s - LAN
- 1990 - World Wide Web (WWW)
- 1996 - Telecommunications Act of 1996
- 1990s - Intranet, Extranet, E-Commerce

Key Telecom Events

- Telegraph
  - First public demonstration in 1844
  - Digital system - dots and dashes
  - Helped put Pony Express out of business
    - Pony Express lasted less than 1 year
- Telephone
  - Demonstrated in 1876
  - Analog system

Key Telecom Events

- AT&T
  - Formed to provide long-distance service between local Bell telephone companies
  - AT&T bought the local Bell telephone companies and formed the Bell System
    - 22 Bell operating companies (BOCs)
  - Became a "legal" monopoly by about 1900
- Federal Communications Commission (FCC)
  - Formed by The Communications Act of 1934
  - Regulates telephone tariffs for *interstate* and *international* traffic
  - Does not regulate within the state
    - This is the job of Public Utility Commission (PUC) or Public Service Commission (PSC)

Key Telecom Events

- ARPANET
  - Experimental, highly-redundant data network
  - Collaboration of universities, research institutions, and federal government
  - Sponsored by Advanced Research Projects Agency(ARPA) in U.S. Department of Defense
  - Packet switched network
  - Predecessor of the Internet

Key Telecom Events

- AT&T Divestiture
  - Culmination of years of effort to prove AT&T violated Sherman Anti-Trust Act
  - 1982 Consent Decree defined how AT&T would be divested
  - 1984 Modified Final Judgement (MFJ) provided detail of divestiture
  - After reorganization
    - 22 BOCs organized under 7 Regional Bell Operating Companies (RBOCs)
      - Handled local telephone traffic
      - How many RBOCs are there today?
    - AT&T spun off Lucent Technologies
    - Remaining AT&T handled long-distance traffic

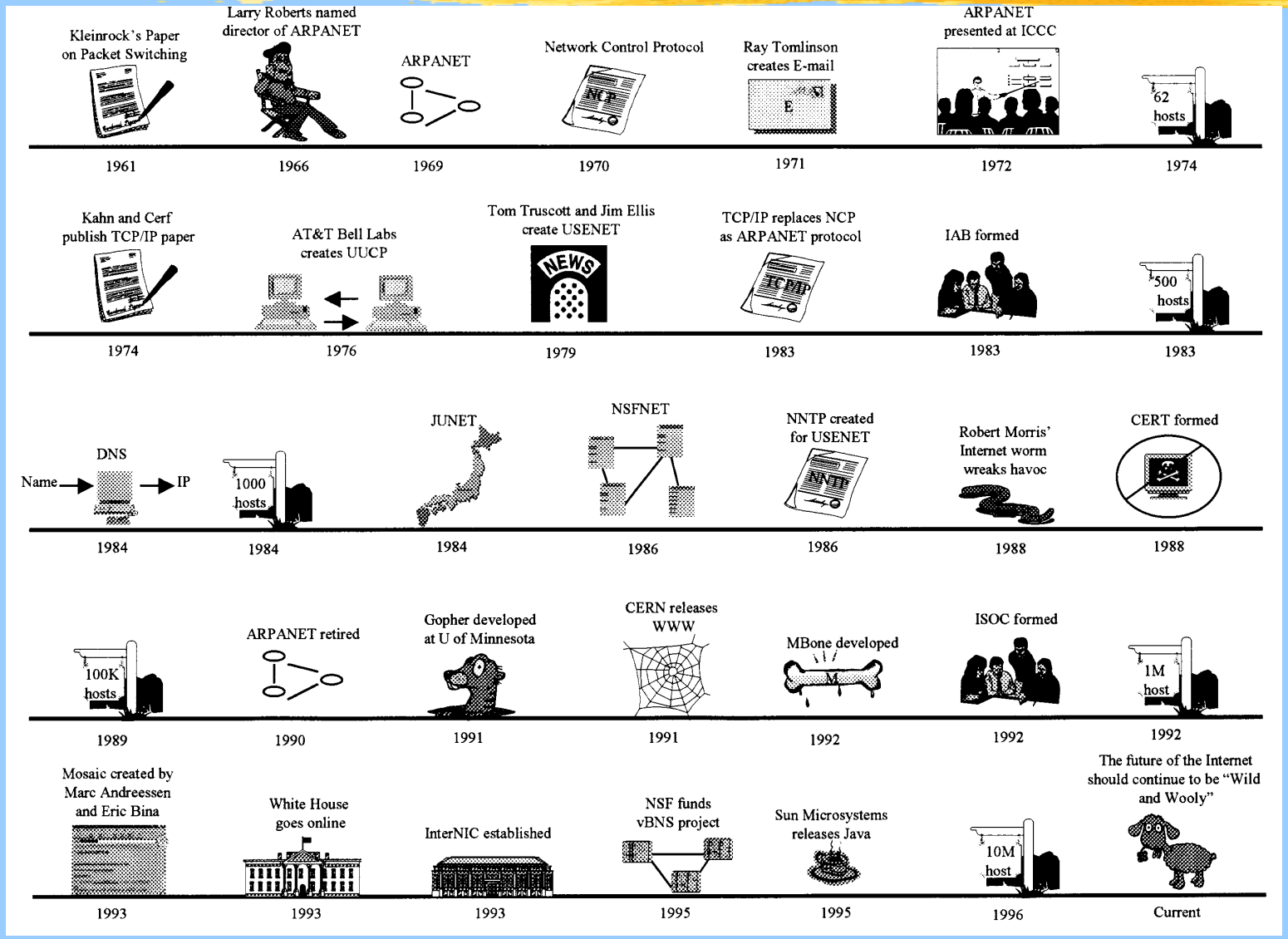
Key Telecom Events

- Telecommunications Act of 1996
  - Shifted authority to interpret and enforce communications policy from courts and other regulatory bodies to FCC
  - Penalties for knowingly transmitting obscene material to persons under 18
  - Terminate regulation of cable television rates on March 31, 1999
  - Prevention of exclusion of new or existing companies desiring to provide interstate and intrastate telecommunication services
  - Permission for RBOCs to offer interregional and intraregional long distance services
  - BOCs required to resell their services to permit competitors access to local markets
  - Ended ban on cross-ownership of cable and telephone companies in rural communities

Telecom, Government Regulation, and Industry Standards

- Telecommunications development due to three factors
  - Technology & innovation
  - Government regulations
  - Industry standards
- Government regulation is a key component in telecommunications infrastructure development
- Systems and equipment designed to meet industry standards so it is readily accepted by customers
- Industry standards fit within government regulations
- Companies with new technology try to influence standards to embody their technology

Internet Timeline



Key Internet Events

- 1961 - Leonard Kleinrock publishes paper on packet switching
- 1969 - ARPANET test
- 1970 - Network Control Protocol (NCP) implemented on ARPANET
- 1971 - E-mail
- 1974 - Kahn and Cerf publish paper on TCP/IP
- 1974 - 62 hosts on ARPANET
- 1979 - USENET newsgroup network

Key Internet Events

- 1983 - Internet Activity Board (IAB) created to oversee protocol development
- 1983 - TCP/IP version 4 adopted for ARPANET
- 1983 - 500 hosts
- 1984 - Domain Name System (DNS)
- 1986 - National Science Foundation Network (NSFNET)
- 1988 - Worm virus
- 1988 - Computer Emergency Response Team (CERT)
- 1990 - ARPANET retired

Key Internet Events

- 1991 - Gopher menu-driven Intenet interface
- 1991 - Tim Berners-Lee develops World Wide Web
- 1992 - 1,000,000 hosts
- 1993 - Mosaic graphical WWW interface
- 1993 - Internet Network Information Center (InterNIC)
- 1993 - 2,000,000 hosts
- 1995 - NSF stops supporting NSFNET
  - Internet goes commercial
  - Internet Service Providers (ISPs)

Key Internet Events

- 1995 - NSF starts supporting Very-High-Speed Backbone Network Service (vBNS)
- 1996 - Telecommunications Act of 1996
- 1996 - 10,000,000 hosts
- 1997 to present - E-commerce, distance learning, Voice-Over-IP, Virtual Private Networks, etc.

Key Internet Events

- Kleinrock's packet switching paper
  - Defined technique to transport data efficiently over a network
- ARPANET
  - Proves that computer data networks can work
- Transmission Control Protocol / Internet Protocol (TCP/IP)
  - Efficient internet protocol developed
  - Replaces old Network Control Protocol
  - Version 4 adopted for ARPANET in 1983
    - Still used today with enhancements

Key Internet Events

- Internet Activities Board (IAB) now Internet Architecture Board
  - Formed to control developments in TCP/IP internetworking standards
  - Uses Requests For Comment (RFC)
    - An RFC first appears as a "proposed" standard
    - Comments from interested people received
    - Original RFC may be modified and put in refined form as new RFC
    - Final RFC version can be adopted as an Internet *standard*
      - Known as STD RFC
  - Internet Engineering Task Force (IETF) - 1986
    - Handles logistics of managing RFCs
    - See http://www.ietf.org
    - Follow link to "Tao"

Key Internet Events

- DNS
  - Server provides translation between a computer name and its Internet Protocol (IP) address
- NSFNET (1986-1995)
  - Network designed to support academic and research communities
  - Supercomputer sites put on backbone
    - Originally 56kbps
  - Marked beginning of fast growth of Internet

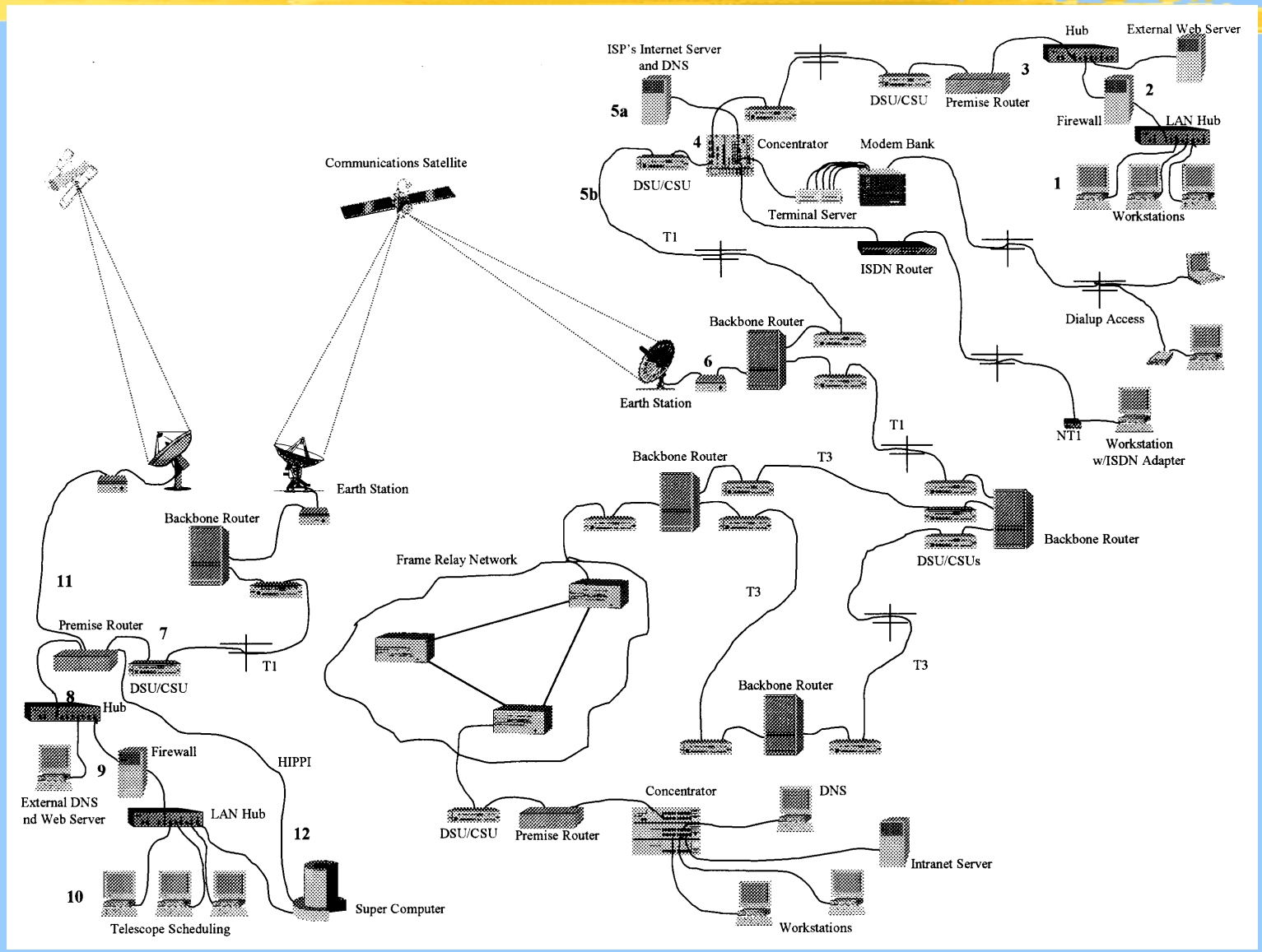
Key Internet Events

- World Wide Web
  - Tim Berners-Lee proposed it as a means to share information between scientists
- Mosaic
  - Graphical interface for WWW
  - Attracted many new users, including industry
- Telecommunications Act of 1996
  - Changed landscape for infrastructure development
    - Help provide high bandwidth to home
    - Concept of “Universal Service” applied to Internet
  - Opened door for commercial use of Internet

Internet Components

- Perspectives for viewing and studying the Internet
  - Telecommunications backbone
  - Connectivity options
  - Services
    - Includes security issues, protocol issues

Internet Components



Internet Backbone Overview

- Internet backbone is a wide-area network (WAN)
- There are many protocols used for moving data across the Internet backbone
- Most backbone links use point-to-point or switched telecommunications *links*
  - A particular link may permit different data link protocols to operate across it, but not at the same time
    - Example: a fiber can run OC3 or OC12 across it

Packet Switching Analogy

- A communication session between two Internet entities can involve many packets transmitted between them
  - Analogy is like U.S. Postal Service
    - Packets are like letters
    - Destination address says where letter goes
    - Intermediate post offices route the letter to final destination
- Routers are packet switches
  - Act like intermediate post offices in mail system
  - Backbone links connect to routers

Internet Access

- Users need a way to access the backbone to communicate across network
  - Internet service providers (ISP) provide access
  - ISPs can provide different levels of service based on cost
    - High capacity for large companies
    - Low capacity for small companies and individuals

Internet Access

- Routers and concentrators often used to connect local-area networks (LANs) and the ISP
  - Concentrator concentrates different technologies on single chassis
  - Router can be a concentrator because it can interface to different networks
- Link to ISP from customer requires interface devices that operate with the correct data link protocol
  - 56kbps analog modem
  - ISDN modem (a.k.a. ISDN terminal adapter or digital modem)
  - T1 DSU/CSU (sometimes called CSU/DSU)

Internet Example

- Web access to remote telescope array
  - See text pp. 22-23

Some Major Players

- Infrastructure
  - WAN
    - MCI, AT&T, Bell Companies, British Telecom (BT), Nippon Telegraph and Telephone (NTT)
  - Computers
    - IBM, Sun, Apple, Motorola, Intel
  - Data network hardware
    - Cisco, Cabletron, Nortel, U.S. Robotics

Some Major Players

- Internet Standards
  - Internet Society (ISOC)
    - IAB, IETF part of ISOC
  - Internet Corporation for Assigned Names and Numbers (ICANN)
    - Assigns internet addresses
  - Internet Network Information Center (InterNIC)
    - Handles domain name registration for North America
      - i.e., SPSU in www.spsu.edu
    - Operated by Network Solutions, Inc. (NSI)