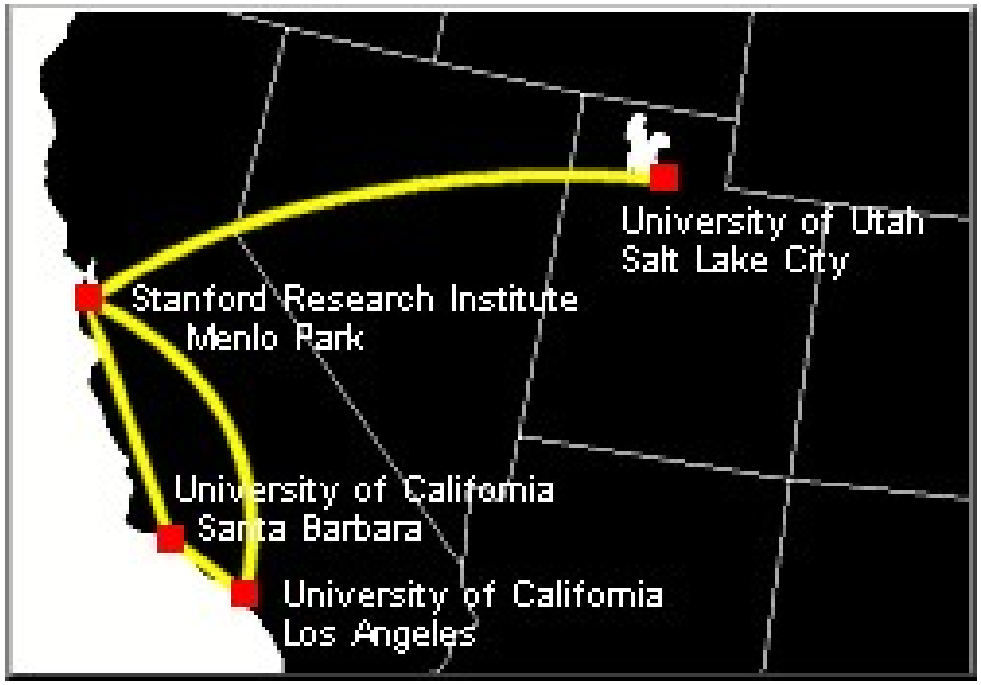
Chapter 15

Networks



ARPANet in 1969

Chapter Goals

- Describe the core issues related to computer networks
- List various types of networks and their characteristics
- Explain various topologies of local-area networks
- Explain why network technologies are best implemented as open systems

Chapter Goals

- Compare and contrast various technologies for home Internet connections
- Explain packet switching
- Describe the basic roles of various network protocols
- Explain the role of a firewall
- Compare and contrast network hostnames and IP addresses
- Explain the domain name system

Networking

- **Computer network** A collection of computing devices that are connected in various ways in order to communicate and share resources

  Usually, the connections between computers in a network are made using physical wires or cables

  - However, some connections are **wireless**, using radio waves or infrared signals

Networking

- The generic term **node** or **host** refers to any device on a network
- **Data transfer rate** The speed with which data is moved from one place on a network to another
- Data transfer rate is a key issue in computer networks

Networking

- Computer networks have opened up an entire frontier in the world of computing called the **client/server model**

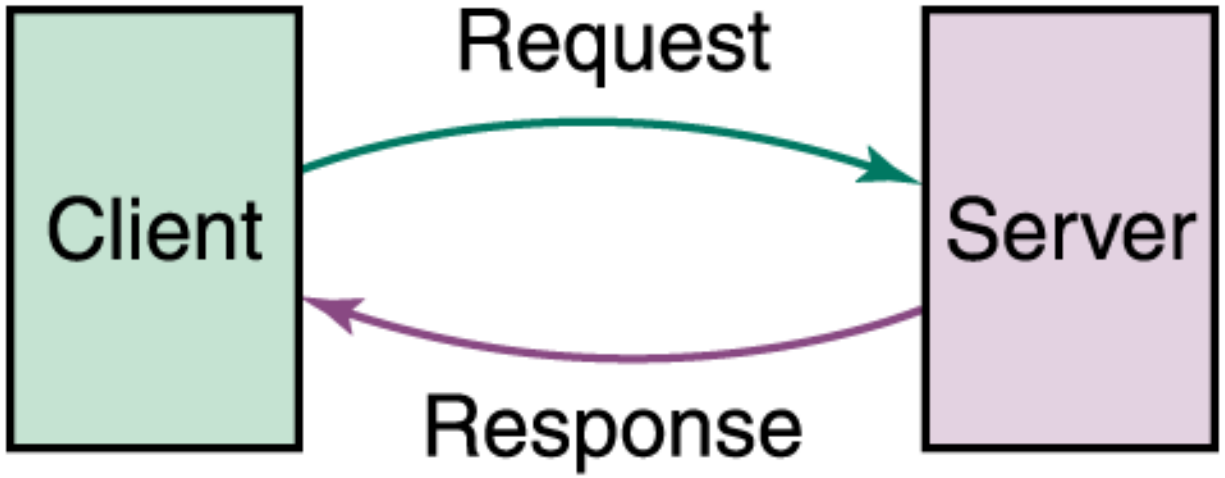


Figure 15.1 **Client/Server interaction**

Networking

- **File server** A computer that stores and manages files for multiple users on a network
- **Web server** A computer dedicated to responding to requests (from the browser client) for web pages

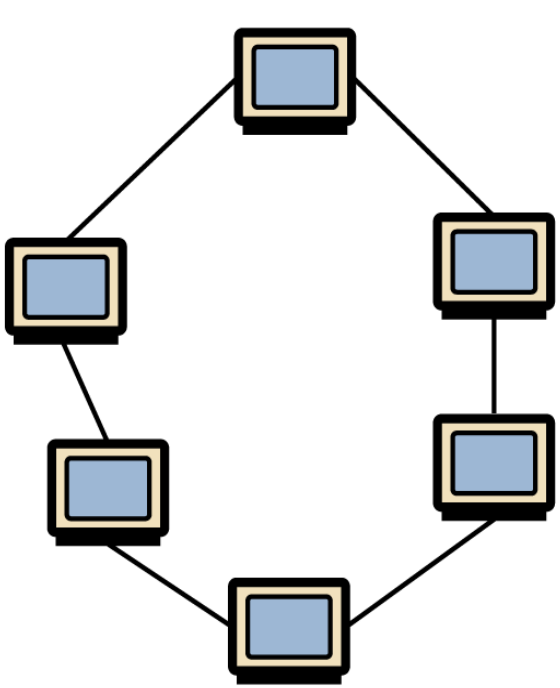
Types of Networks

- **Local-area network (LAN)** – A network that connects a relatively small number of machines in a relatively close geographical area
- **Wide-area network (WAN)** – A network that connects many machines over a large (or wide) geographical area

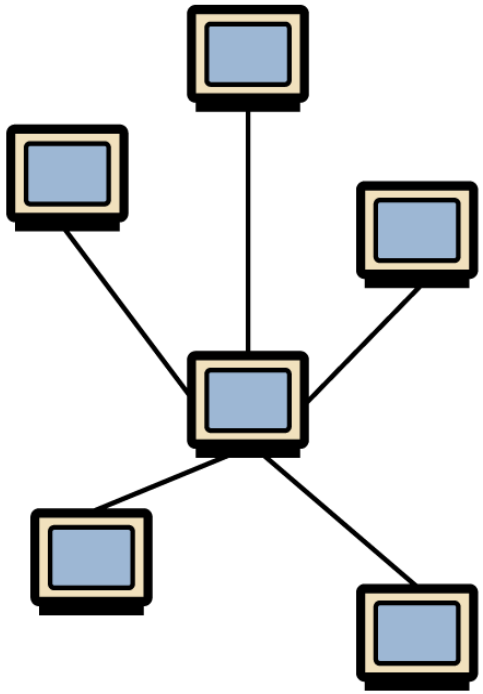
Topology of Networks

- Various configurations, called topologies, have been used to administer LANs
  - **Ring topology** A configuration that connects all nodes in a closed loop on which messages travel in one direction
  - **Star topology** A configuration that centers around one node to which all others are connected and through which all messages are sent
  - **Bus topology** All nodes are connected to a single communication line that carries messages in both directions

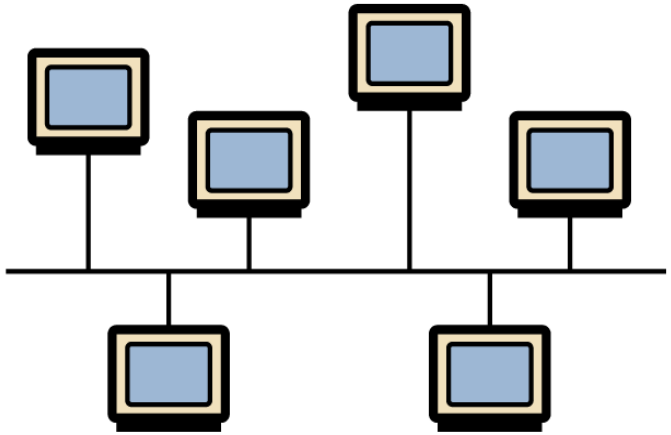
Types of Networks



Ring topology



Star topology



Bus topology

- A bus technology called **Ethernet** has become the industry standard for local-area networks

Types of Networks

- **Wide-area network (WAN)** A network that connects two or more local-area networks over a potentially large geographic distance

  Often one particular node on a LAN is set up to serve as a **gateway** to handle all communication going between that LAN and other networks

- Communication between networks is called **internetworking**

  The **Internet,** as we know it today, is essentially the ultimate wide-area network, spanning the entire globe

Types of Networks

- **Metropolitan-area network (MAN)**
  The communication infrastructures that have been developed in and around large cities
- **Wi-Fi** is a brand originally licensed by the Wi-Fi Alliance to describe the underlying technology of wireless local area networks (WLAN) based on the IEEE 802.11 specifications.

So, who owns the Internet?

Well, nobody does. No single person or company owns the Internet or even controls it entirely. As a wide-area network, it is made up of many smaller networks. These smaller networks are often owned and managed by a person or organization. The Internet, then, is really defined by how connections can be made between these networks.

Types of Networks

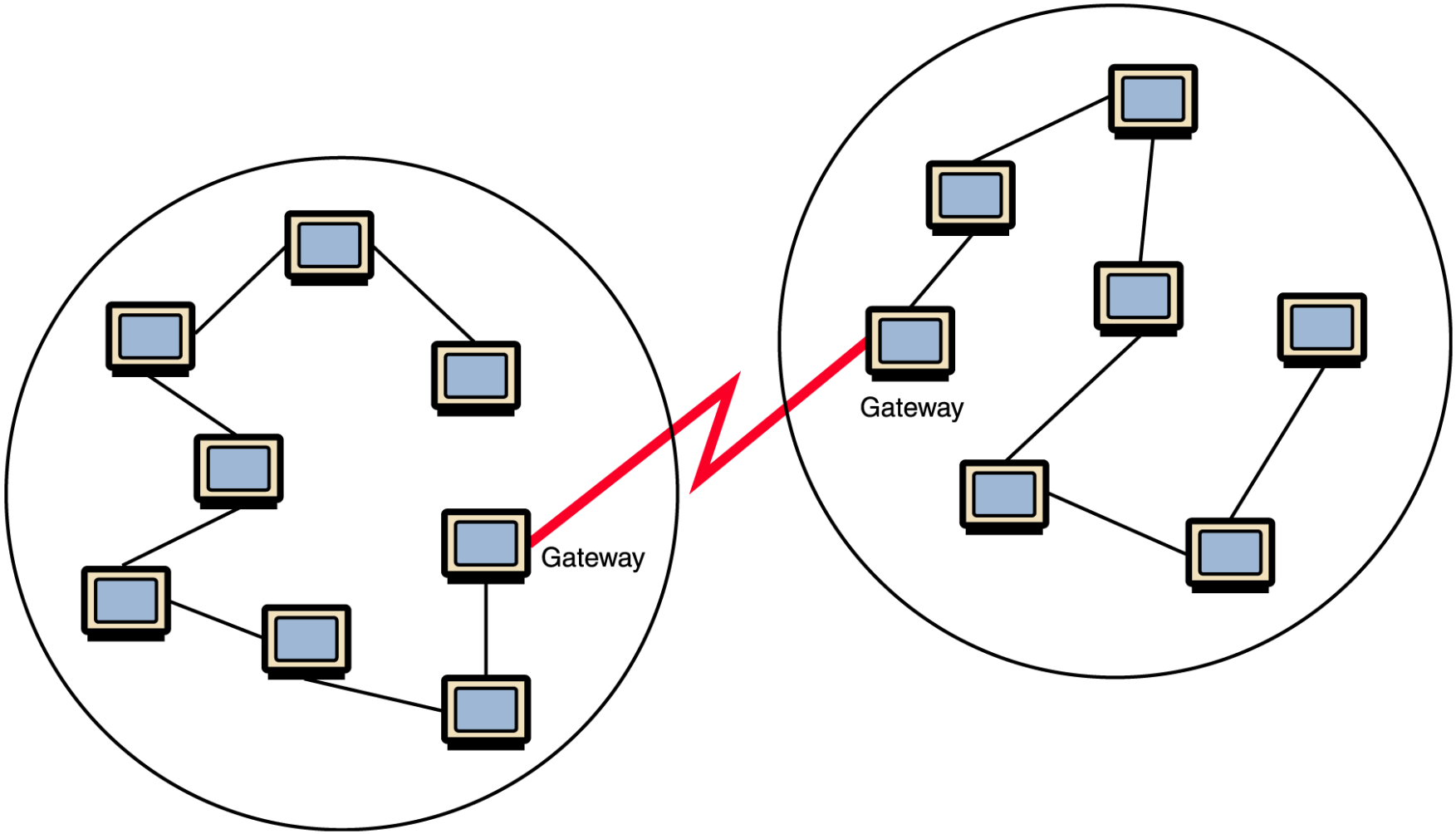


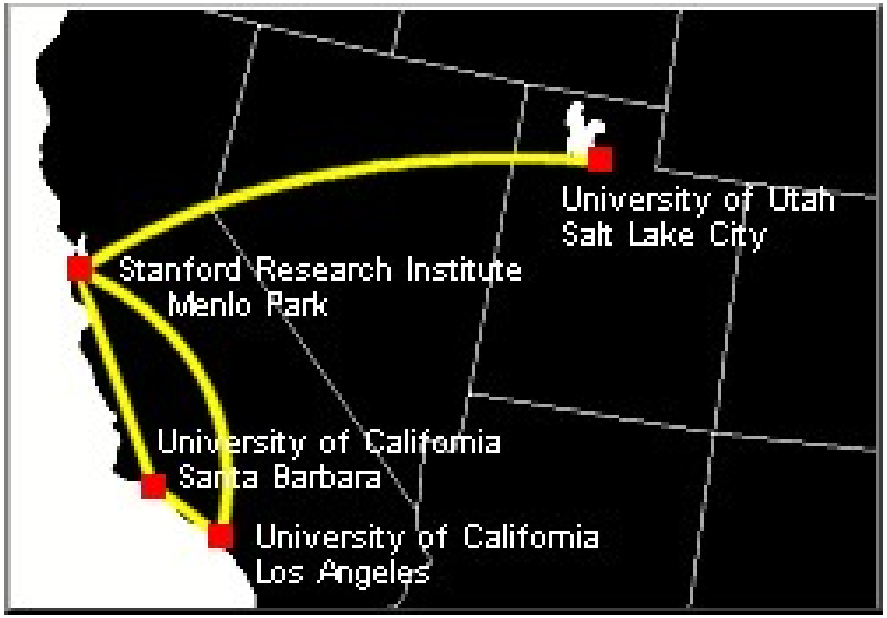
Figure 15.1 **Local-area networks connected across a distance to create a wide-area network**

Internet History

- Evolved from ARPANet (**D**efense Department's **A**dvanced **R**esearch **P**rojects **A**gency Network)
- ARPANet was developed in 1969, and was the first packet-switching network
- Initially, included only four nodes: UCLA, UCSB, Utah, and SRI

The Birth Of The Internet 1969

- Richard Nixon Becomes 37th President
- Jets – SuperBowl III, Miracle Mets
- Neil Armstrong Lands On The Moon
- Woodstock, Altamont, Jazz Fusion
- Chappaquiddick Incident
- Sesame Street Debuts
- Internet Goes Online



ARPANet in 1969

NSF and the Internet

- In the 1980s, **NSFNet** extended packet-switched networking to non-ARPA organization; eventually replaced ARPANet
- Instituted **Acceptable Use Policies** to control use
- **CIX** (Commercial Internet eXchange) was developed to provide **commercial internetworking**

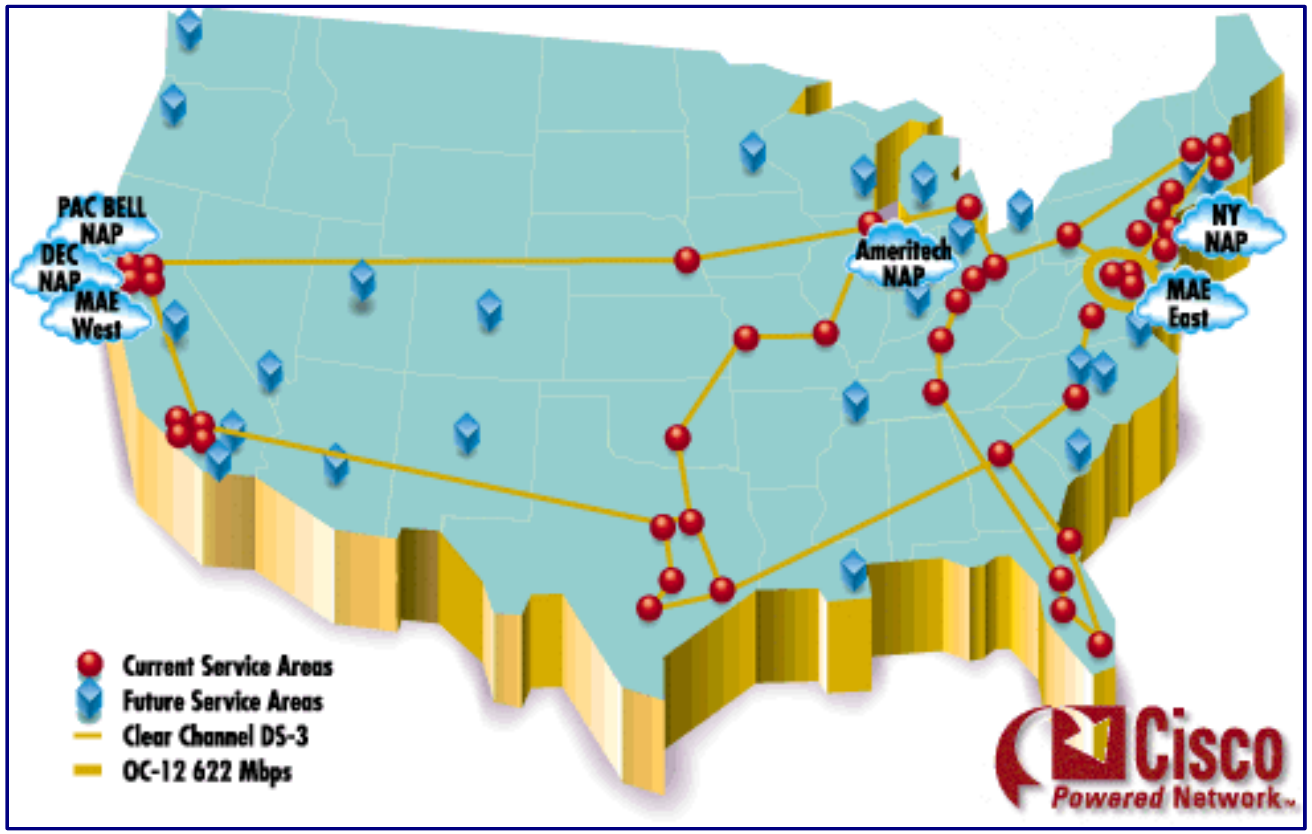
The World Wide Web

- Concept proposed by **Tim Berners-Lee** in 1989, prototype WWW developed at CERN in 1991
- First graphical browser (**Mosaic**) developed by Mark Andreessen at NCSA
- Client-server system with browsers as clients, and a variety of media types stored on servers
- Uses **HTTP** (**H**yper **T**ext **T**ransfer **P**rotocol) for retrieving files

Internet Connections

- **Internet Service Provider (ISP)** A company that provides other companies or individuals with access to the Internet
- ISPs use “wholesalers” called **network service providers** (Juniper, InterNAP) and high speed (T-3 or higher) connections
- **Internet backbone** A set of high-speed networks that carry Internet traffic

US Internet Access Points



Internet Connections

- There are various technologies available that you can use to connect a home computer to the Internet
  - A **phone modem** converts computer data into an analog audio signal for transfer over a telephone line, and then a modem at the destination converts it back again into data
  - A **digital subscriber line** **(DSL)** uses regular copper phone lines to transfer digital data to and from the phone company's central office
  - A **cable modem** uses the same line that your cable TV signals come in on to transfer the data back and forth

Internet Connections

- **Broadband** A connection in which transfer speeds are faster than 128 bits per second
  - DSL connections and cable modems are broadband connections
  - The speed for **downloads** (getting data from the Internet to your home computer) may not be the same as **uploads** (sending data from your home computer to the Internet)

Packet Switching

- To improve the efficiency of transferring information over a shared communication line, messages are divided into fixed-sized, numbered **packets**
- Network devices called routers are used to direct packets between networks

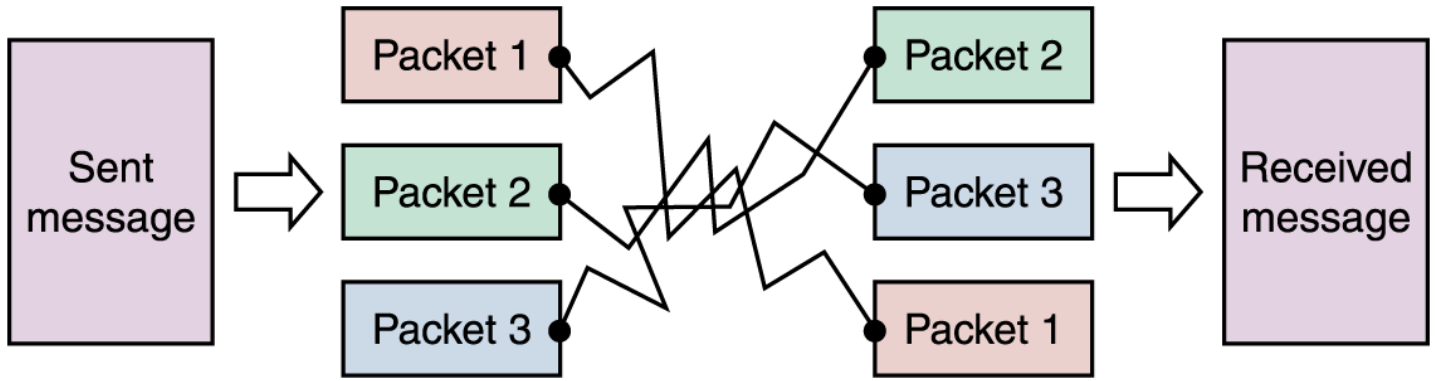


Figure 15.4
Messages sent by packet switching

Open Systems

- **Proprietary system** A system that uses technologies kept private by a particular commercial vendor

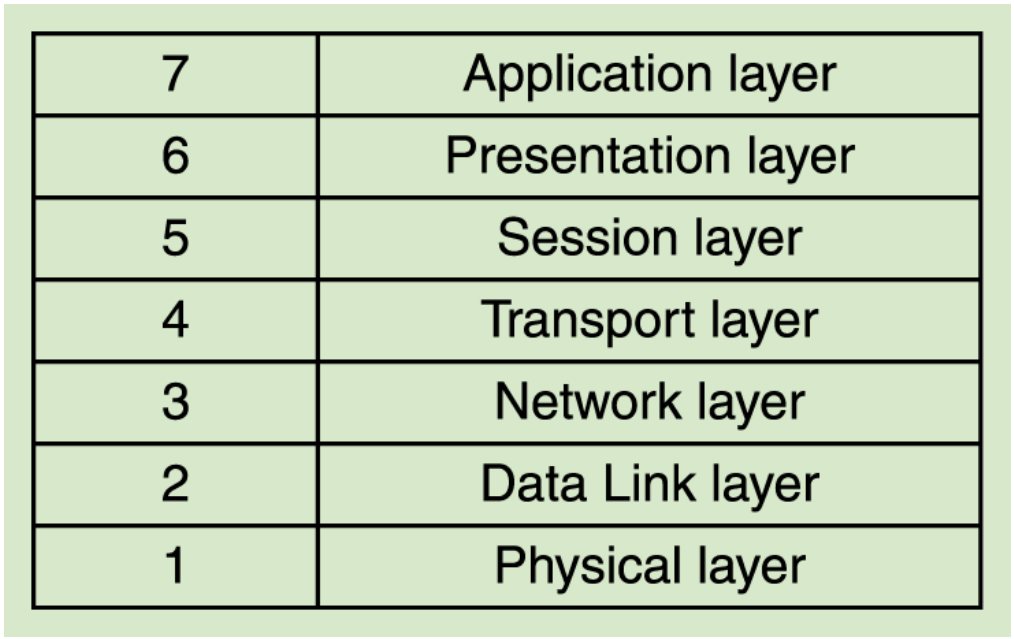
  One system couldn't communicate with another, leading to the need for...

- **Interoperability** The ability of software and hardware on multiple machines and from multiple commercial vendors to communicate

  Leading to...

- **Open systems** Systems based on a common model of network architecture and a suite of protocols used in its implementation

Open Systems



7	Application layer
6	Presentation layer
5	Session layer
4	Transport layer
3	Network layer
2	Data Link layer
1	Physical layer

Figure 15.5 **The layers of the OSI Reference Model**

- The International Organization for Standardization (ISO) established the **Open Systems Interconnection (OSI) Reference Model**
- Each layer deals with a particular aspect of network communication

Network Protocols

- Network protocols are layered such that each one relies on the protocols that underlie it
- Sometimes referred to as a **protocol stack**

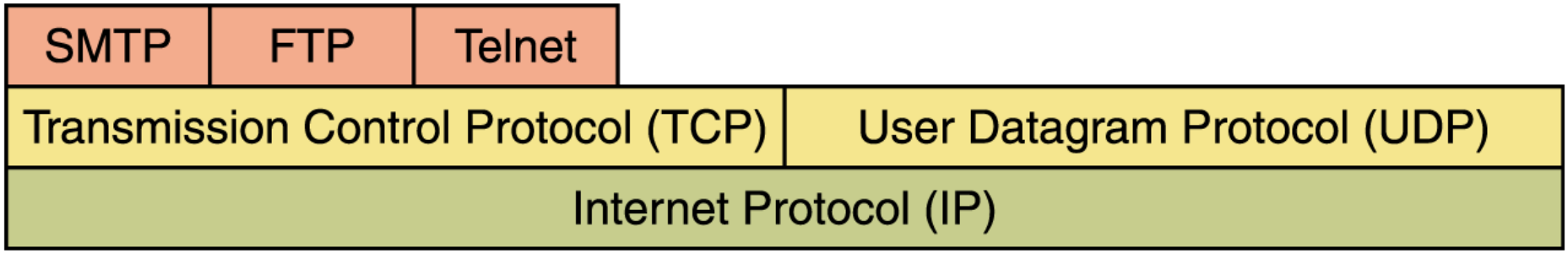


Figure 15.6 **Layering of key network protocols**

TCP/IP

- TCP stands for **Transmission Control Protocol**

  TCP software breaks messages into packets, hands them off to the IP software for delivery, and then orders and reassembles the packets at their destination

- IP stands for **Internet Protocol**

  IP software deals with the routing of packets through the maze of interconnected networks to their final destination

TCP/IP (cont.)

- UDP stands for **User Datagram Protocol**
  - It is an alternative to TCP
  - The main difference is that TCP is highly reliable, at the cost of decreased performance, while UDP is less reliable, but generally faster

High-Level Protocols

- Other protocols build on the foundation established by the TCP/IP protocol suite
  - Simple Mail Transfer Protocol (SMTP)
  - File Transfer Protocol (FTP)
  - Telnet
  - Hyper Text Transfer Protocol (http)

MIME Types

- Related to the idea of network protocols and standardization is the concept of a file's MIME type
  - MIME stands for **Multipurpose Internet Mail Extension**
  - Based on a document's MIME type, an application program can decide how to deal with the data it is given

MIME Types

Protocol	Port
Echo	7
File Transfer Protocol (FTP)	21
Telnet	23
Simple Mail Transfer Protocol (SMTP)	25
Domain Name Service (DNS)	53
Gopher	70
Finger	79
Hyper Text Transfer Protocol (HTTP)	80
Post Office Protocol (POP3)	110
Network News Transfer Protocol (NNTP)	119
Internet Relay Chat (IRC)	6667

Figure 15.7
Some protocols and the ports they use

Firewalls

- **Firewall** A machine and its software that serve as a special gateway to a network, protecting it from inappropriate access
  - Filters the network traffic that comes in, checking the validity of the messages as much as possible and perhaps denying some messages altogether
  - Enforces an organization's **access control policy**

Firewalls

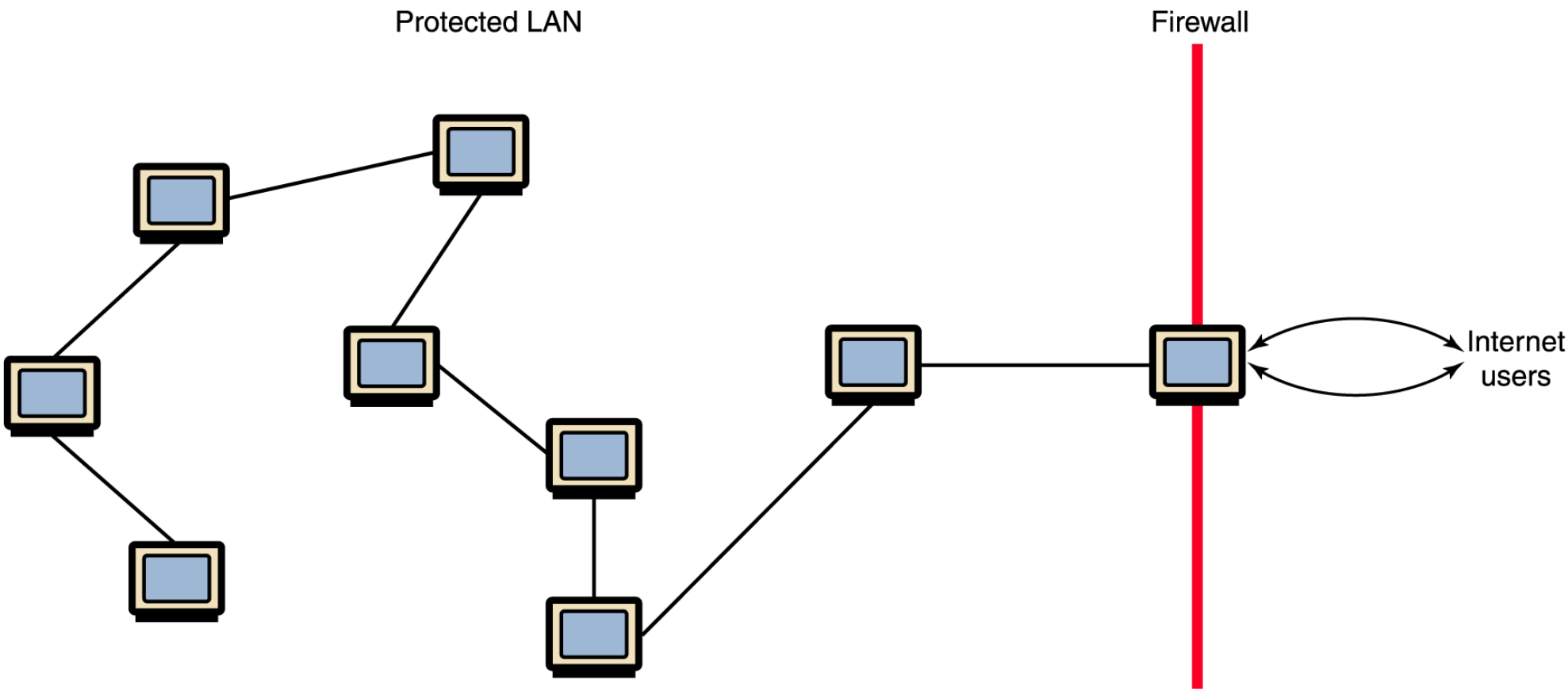


Figure 15.8 **A firewall protecting a LAN**

Network Addresses

- **Hostname** A unique identification that specifies a particular computer on the Internet

  For example

  matisse.csc.villanova.edu

  condor.develocorp.com

Network Addresses

- Network software translates a hostname into its corresponding IP address

> **www.hofstra.edu**
> Server: ns.cv.net
> Address: 167.206.1.30
>
> Non-authoritative answer:
> **Name: www.hofstra.edu**
> **Address: 147.4.20.231**
>
> > **myspace.com**
> > Server: ns.cv.net
> > Address: 167.206.1.30
> >
> > Non-authoritative answer:
> > **Name: myspace.com**
> > **Addresses: 216.178.32.48, 216.178.32.49, 216.178.32.50, 216.178.32.51**

Network Addresses

- A 32-bit **IP address** can be split into
  - **network address**, which specifies a specific network
  - **host number**, which specifies a particular machine in that network

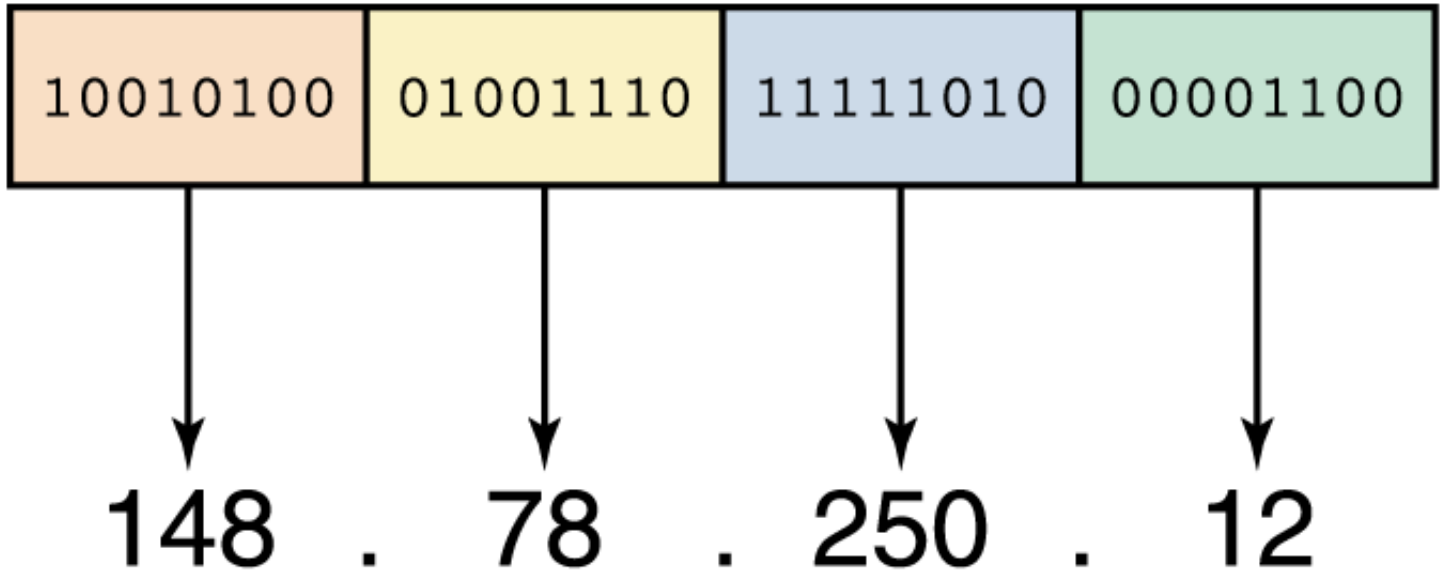
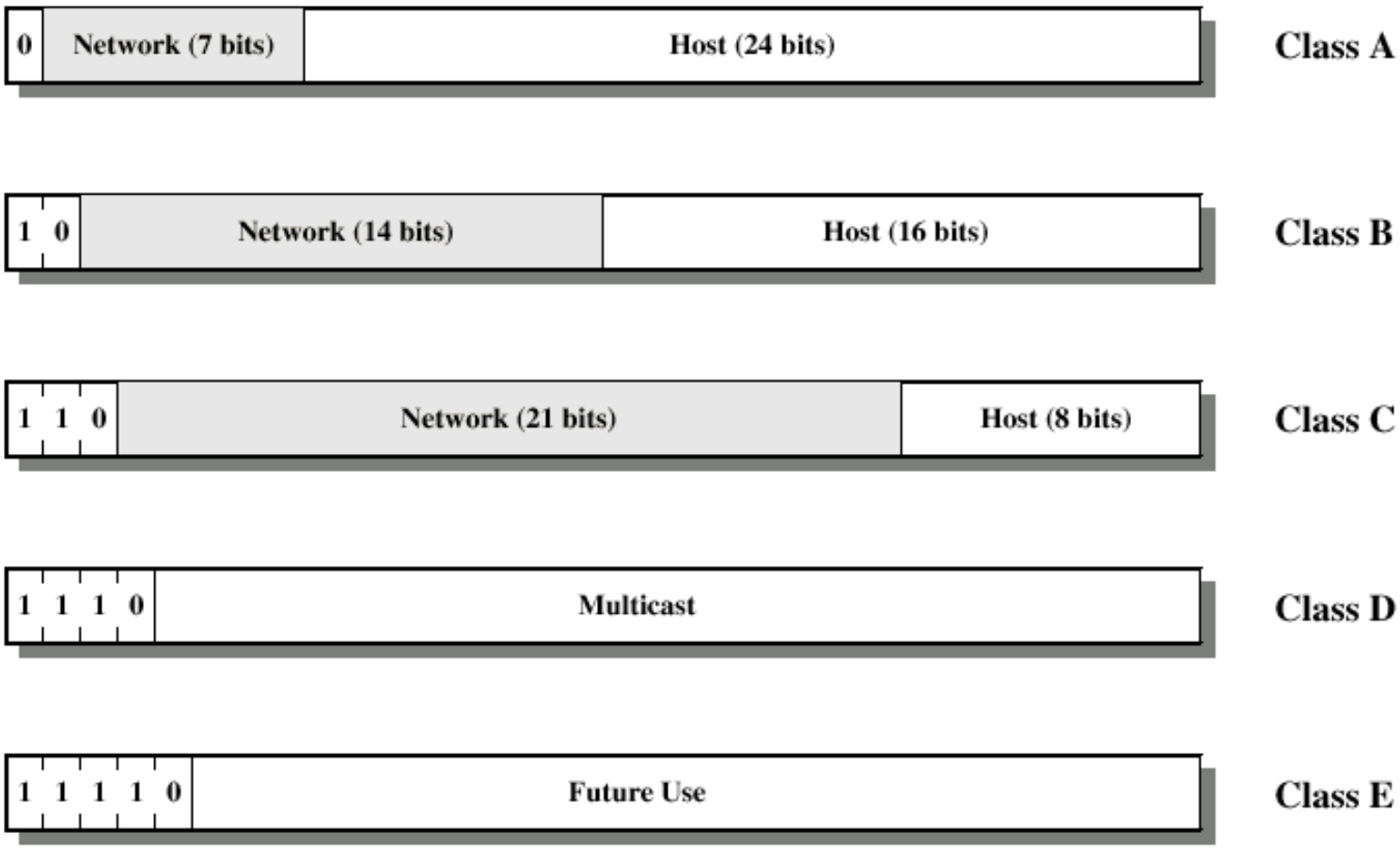


Figure 15.9
An IP address is stored in four bytes

Internet Addressing



Network Classes

- **Class A:** Few networks, each with many hosts
  All addresses begin with binary 0
  Range: 1-126
- **Class B:** Medium networks, medium hosts
  All addresses begin with binary 10
  Range: 128-191
- **Class C:** Many networks, each with few hosts
  All addresses begin with binary 11
  Range: 192-223

Domain Name System

- 32-bit IP addresses have two drawbacks
  - Routers can’t keep track of every network path
  - Users can’t remember dotted decimals easily
- **Domain names** address these problems by providing a name for each network domain (hosts under the control of a given entity)

Domain Name System

- A hostname consists of the computer name followed by the **domain name**
- cs.hofstra.edu is the domain name
  - A domain name is separated into two or more sections that specify the organization, and possibly a subset of an organization, of which the computer is a part
  - Two organizations can have a computer named the same thing because the domain name makes it clear which one is being referred to

Domain Name System

- The very last section of the domain is called its **top-level domain (TLD)** name

Top-Level Domain	General Purpose	New TLDs	General Purpose
.com	U.S. Commercial	.biz	Business
.net	Network	.info	Information
.org	Nonprofit organization	.pro	Professional
.edu	U.S. Educational	.museum	Museums
.int	International	.aero	Aerospace industry
.mil	U.S. Military	.coop	Cooperative
.gov	U.S. Government		

Figure 15.10 **Top-level domains, including some relatively new ones**

Domain Name System

- Organizations based in countries other than the United States use a top-level domain that corresponds to their two-letter country codes

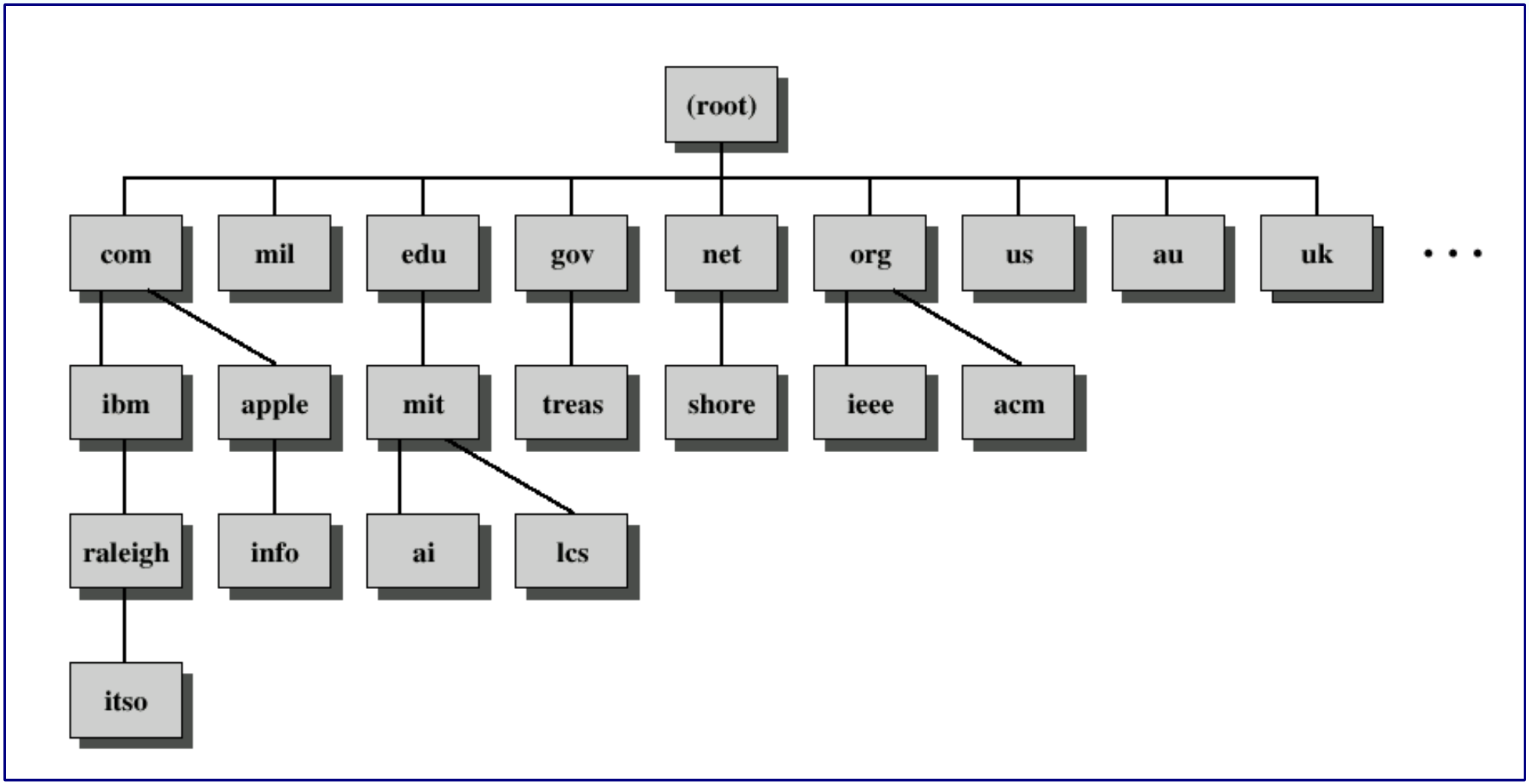
Country Code TLD	Country
.au	Australia
.br	Brazil
.ca	Canada
.gr	Greece
.in	India
.ru	Russian Federation
.uk	United Kingdom

Figure 15.11
Some of the top-level domain names based on country codes

Domain Name System

- The **domain name system (DNS)** is chiefly used to translate hostnames into numeric IP addresses
  - DNS is an example of a distributed hierarchical database
  - If that server can resolve the hostname, it does so
  - If not, that server asks another domain name server

Domain Tree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lcs
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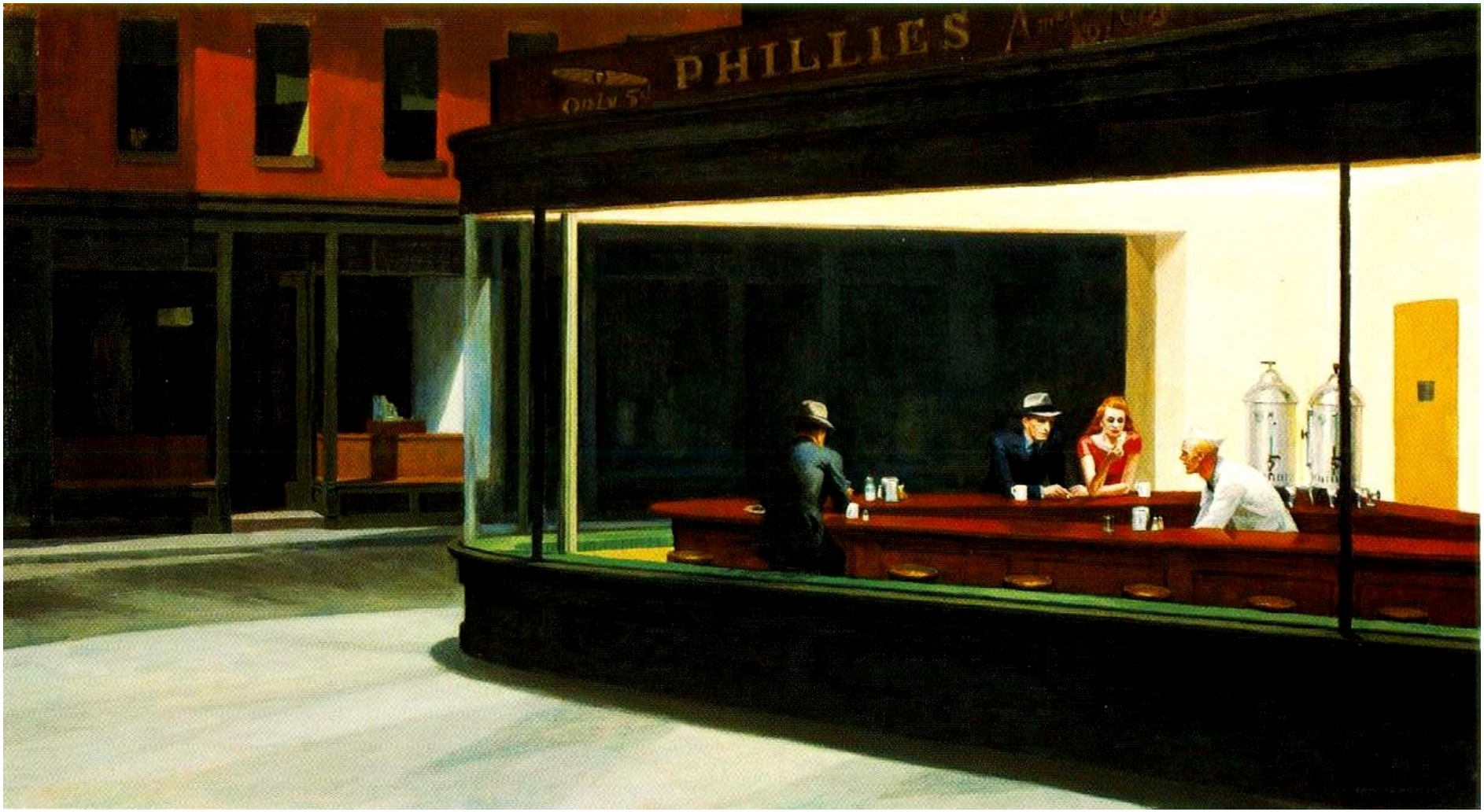
Important URLs

- http://www.networksolutions.com/whois/index.jhtml
  The original InterNIC. This site has the “whois” database
- http://www.arin.net
  American registry for Internet numbers. This site has a “whois” database for IP numbers
- http://www.net.princeton.edu/traceroute.htmlhttp://www.tracert.com/Handy tools: traceroute, ping, nslookup, whois, dig

Homework

- **Read Chapter Fifthteen** – Begin reading...
- ...Next Class We'll Cover **Network Security**

Have A Nice Night



http://www.whitney.org/