In this chapter:
- sending/receiving messages
- network protocols
- addressing mechanisms
- client/server programming
Networks and Graph Theory (an aside)

5 node network

Some Fully Connected Graphs

K1
K2
K3
K4

K5

how many edges for n nodes?
Networking Challenges

• scalability: we can't just directly connect every computer to every other computer on the network

\[ \sum_{i} (i = 0, n-1) = \frac{n(n-1)}{2} \text{ edges} \]

• routing: finding a path from source to destination

• protocols:
  • break up large messages
  • send messages in pieces
  • send along one or more paths
  • reassemble messages as the pieces arrive
1.1 Clients, Servers, and Peers

• Servers provide services (what services?)

• Clients use services (how?)

• Peers (simulated only)
1.3 The Internet and IP Addresses

• An internet is a network of networks

• IP: "Internet Protocol" (a network communication protocol)

• The Internet: the world's largest IP-based network

• Every computing device on the Internet has its own unique IP address

• IP address: e.g., 143.229.6.42
quad notation: n.n.n.n
where each n is an 8-bit number
(range: 0 to 255; 00 to FF)
1.2 Ports and Sockets

• Port:
  - a logical connection to a computer
  - range: $1 \leq \text{port#} \leq 65535$
  - std services: $1 \leq \text{port#} \leq 1023$

• Socket:
  - a communication endpoint
  - an abstract concept; not hardware
  - client creates a socket on its end
  - server creates a socket on its end
1.4 Internet Services, URLs and DNS

• Services are provided by a computer with an IP address

• A computer, in general, could provide many services

• Each service is associated with a port number

• "Famous" port numbers:
  - SSH, 22 (secure shell)
  - smtp, 25 (simple mail transfer prot)
  - HTTP, 80 (hypertext transfer prot)
  - POP3, 110 (post office prot v.3)
1.4 Internet Services, URLs and DNS

• Since most people can't remember big numbers very well...

• DNS: Domain Name System
  -- a mapping from a string to a num
  -- e.g. www.cs.vassar.edu maps to 143.229.6.42

• Can refer to a computer's port via its domain name just as with its IP address
The 4-layer network model
(Fig. 1.1, p. 6)
1.5 TCP

Transmission Control Protocol

- Transport Layer
- error-checking/correcting
- reliable
- takes more time to ensure reliability:
  -- all packets arrive, and put into correct order
1.6 UDP

User Datagram Protocol

• Transport Layer
• no error-checking/correcting
• unreliable: no guarantee of packet arrival or order of arrival
• fast!
• e.g., streaming, live feeds