The Internet

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How does the Internet work?

- What happens when you click on a link in a web browser?
- How does e-mail work?
- How does USENET news work?
- How does telnet work?
- How does ftp work?
- How does X Windows work?
- How does NFS work?
- (How does the MBONE work?)

Networking

- The OSI layers in the real world:
  - Application: HTTP, FTP, SMTP, NNTP, telnet
  - Presentation:
    - MIME (Multipurpose Internet Mail Extensions)
  - Transport:
    - UDP: unreliable, unordered datagrams, port numbers
    - TCP: reliable, ordered byte stream, port numbers
  - Network:
    - IP: best effort routing of packets between any two machines on different networks on the Internet
      - Packets can be dropped, mis-routed, corrupted, duplicated
  - Physical, data link: Ethernet, point-to-point links

Naming

- DNS (Domain Name System)
  - Human-readable name to IP address
  - www.yahoo.com (DNS) -> 204.71.200.74 (IP)
- ARP (Address Resolution Protocol)
  - IP address to data link address
  - 204.71.200.74 (IP) -> 80:0:2b:e4:b1:2 (Ethernet)

Internet Programming: Sockets

- Client:
  - fd = socket(type of socket);
  - connect(fd, address);
  - write(fd, buffer, len);
  - read(fd, buffer, len);
  - close(fd);
- address =
  - IP address + port number
- Original “sockets”: BSD
- “Winsock”: Windows

- Server:
  - fd = socket(type of socket);
  - bind(fd, address);
  - listen(fd, backlog);
  - newfd = accept(fd, addr);
  - read(fd, buffer, len);
  - write(fd, buffer, len);
  - close(newfd);
  - close(fd);

Remote login: Telnet

- Remote login protocol
- Single TCP connection to port 23 of server
- UNIX
- Client:
  - sends keystrokes over socket
  - receives echo from server
- Server
  - receives keystrokes over socket, sends to process
  - sends output over socket

E-mail: SMTP

- SMTP: Simple Mail Transfer Protocol
- Single TCP connection to server at port 25
  - HELO myhost.cs.washington.edu
  - MAIL FROM: me@cs
  - RCPT TO: cse451@cs
  - DATA
  - Isn’t SMTP cool?
  - .
  - QUIT

The Web: HTTP

- HTTP: Hypertext Transfer Protocol
- Single TCP connection to server at port 80
- HTTP 1.0: one connection per HTML, GIF, …
- Client asks for document, server sends:
  - GET index.html HTTP/1.0\n
  - \n
  - <server spews document…>
- Try it!

File transfer: FTP

- FTP: File Transfer Protocol
- Initial TCP connection to port 21 of server
- Client sends commands (cd, ls) over socket
- Client can get or put files
- Actual file transmission over a new socket

News: NNTP

- NNTP: Network News Transfer Protocol
- Servers exchange articles from groups
- Clients ask about, download, post articles
- Single TCP connection to port 119
  - NEWNEWS alt.os 971204 030000
  - ARTICLE <123@orcas.cs.washington.edu>
  - POST
  - <body of article>
  - QUIT

X-Windows

- Portable networked windowing standard
- Server on UNIX, PC, Mac:
  - Program managing screen, keyboard, mouse
  - Listens for drawing, input commands on TCP port 6000
- Client applications on UNIX:
  - xterm, emacs, netscape, xclock, xbiff …
  - Connect to server on port 6000
    - send drawing commands
    - ask for mouse coordinates, keyboard presses
- Window Manager:
  - Special client handles borders, focus: fvwm, twm,…

File Systems: NFS

- NFS: Network File System
- Sun RPC over UDP over LAN
- Client:
  - Module in file system in kernel
  - RPCs made in clear text (!):
    - LOOKUP, GETATTR, SETATTR
    - READ, WRITE, READDIR
    - CREATE, REMOVE, MKDIR, RMDIR
- Server:
  - Stateless module in kernel accepts RPCs

Internet Standards

- RFCs: Requests for comment
  - Numbered documents specifying *all* Internet standards
  - ex: RFC 791 = IP, RFC 793 = TCP (1981)
  - Can be found on the web: http://www.internic.net/
- Well-known ports for TCP, UDP services
  - Numbered 1-1023
  - In UNIX,
    - only root can bind socket to these ports
    - servers started by scripts at boot time
    - /etc/services lists the ports

Internet Tools

- Try these on orcas/sanjuan:
  - /usr/sbin/netstat
  - /usr/sbin/tcpdump
  - /usr/sbin/ping
  - /usr/sbin/traceroute
  - nslookup
  - telnet

Summary

- The Internet works because
  - IP is lowest-common denominator
  - TCP provides nearly everything you need
  - Simple client-server interaction
- Do try this at home:
  - traceroute, ping
  - telnet to port 80