Announcements

- **Handouts (reminder from last time)**
  - class syllabus (on web page)
  - programming assignment #1 (also on web page)
- **Enrollment**
  - Now 10 on the waitlist

Design Issues In Layers

- **Rules for data transmission (Protocol)**
  - full vs. half duplex
  - error control (detection, correction, etc.)
  - flow control (rate matching, overuse of shared resources)
  - message order (do things arrive in the same order as sent?)
- **Abstractions for communications**
  - end points for communication
    - switches, nodes, processes, threads in a process
    - how are these end points named (addresses)?
  - service providers and service users
- **Service Primitives**
  - operations performed by a layer
    - events and their actions
  - request, indication, response, confirm

Protocols are divided into layers

- ISO - seven layer reference model
  - Application
  - Presentation
  - Session
  - Transport
  - Network
  - Link
  - Physical

- TCP/IP - four layer model
  - link
  - network
  - transport/session/presentation
  - application

- Old Saying: If you know what you are doing, four layers is enough; if you don't seven won't help.

Physical Layer

- **Goal: Raw bits over a communication channel**
- **Sample Issues:**
  - how to encode a 0 vs. 1?
  - what voltage should be used?
  - how long does a bit need to be signaled?
  - what does the cable, plug, antenna, etc. look like?
- **Examples:**
  - modems
  - "knock once for yes, twice for no"

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Data Link Layer

- Goal: transmit error free frames over the physical link
- Sample Issues:
  - how big is a frame?
  - can I detect an error in sending the frame?
  - what demarks the end of the frame?
  - how to control access to a shared channel?
- Examples:
  - Ethernet framing

The Network Layer

- Goal: controlling operations of the subnet
- Sample Issues:
  - how route packets that have to travel several hops?
  - control congestion - too many messages at once
  - accounting - charge for use of the network
  - fragment or combine packets depending on rules of link layer
- Examples:
  - IP

The Transport Layer

- Goal: accurately transport session data in order
  - end points are the sending and receiving machines

- Sample Issues:
  - how to order messages and detect duplicates
  - error detection (corrupt packets) and retransmission

- Examples:
  - TCP

The Session & Presentation Layers

- Goal: common services shared by several applications
- Sample Issues:
  - network representation of bytes, ints, floats, etc.
  - encryption?? (this point is subject to lots of debate)
  - synchronization
- Examples:
  - eXternal Data Representation (XDR)

Application Layer

- Goal: common types of exchanges standardized
- Sample Issues:
  - when sending email, what demarks the subject field
  - how to represent cursor movement in a terminal
- Examples:
  - Simple Mail Transport Protocol (SMTP)
  - File Transfer Protocol (FTP)
  - Hyper-Text Transport Protocol (HTTP)
  - Simple Network Management Protocol (SNMP)
  - Network File System (NFS)
  - Network Time Protocol (NTP)
  - Net News Transport Protocol (NNTP)
  - X (X Window Protocol)

Arpanet

- First "public" wide area network
- Ideas Pioneered
  - packet switching
  - internetworking
    - radio, wire, satellite
  - build it before you standardize it!
  - many routing, congestion control, and management ideas
- Dates: 1969-1987
- How to get connected: have a DOD Arpa Contract
- Technology
  - 56 kbps dedicated links
  - custom built network switches (called IMPS)

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NSFNet

- First general audience "public" wide area network
- Ideas Pioneered
  - wide area networking for the masses
  - TCP/IP Wan
  - backbone wide area network connecting regional nets
- Dates: 1984-1995
- How to get connected: be an academic site and join a regional network
- Technology
  - 448kbps - 45 Mbps
  - general purpose workstations as routers

Internet

- **Ideas Pioneered**
  - multi-vendor public networks
  - if you build it they will come!
- **Dates: 1983- (TCP/IP protocol first used)**
- **How to get connected: stop by the mall, call 1-800...**
- **Technology**
  - 9.6kbps to OC-192+ (10+ Gbps)
    - soon higher AND lower speeds will be supported
  - custom routers from many vendors
  - general computers for some routing