Home work project #1

- Develop and fully debug your program on the Cushing 208 lab. Machines - planet lab machines may not have good development environment
- Apply for a account in planet-lab at
  - https://www.planet-lab.org/db/accounts/showaup.php
  - Remember, you are signing a document agreeing to the acceptable use policy. Basically, most anything that you can do within ND is acceptable.
  - Once I receive your application, I will enable your account
- Once your account is enabled, login using the password that you had chosen and upload the ssh public key (by clicking on “Manage keys” option). Instructions on how to create a key is available at
  - https://www.planet-lab.org/db/accounts/showaup.php

- Once your key is uploaded, you will be able to login to the class account using the command

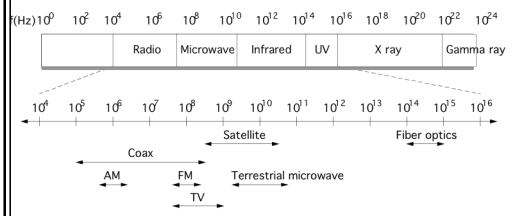
  ssh -l notredame_cse364 <planetlab node>
- Copy your program that you compiled in Cushing 208 machines to run your experiments over the wide area network
- Run your client-server experiments between two planetlab machines. Remember, the results will have wide variance, always repeat your experiments and report the standard deviations and means
  - Use ping command to validate your RTT results

Outline for today

- Direct link networks: On physically connecting nodes
- Hardware building blocks (Chapter 2.1)
  - Common link technologies (more technical details later)
  - Even more details in Data networking course
- Encoding (Chapter 2.2)
  - How are bits transmitted
- Framing (Chapter 2.3)
  - How do we know the boundaries of transmissions

Link hardware

- Signals are propagated as electromagnetic signals
  - These signals have different frequencies



Cables

- Cable technologies: e.g. Cat-5, Cat-6 etc for Ethernet, Fiber for optical
  - Each technology has limitations on range and bandwidth carrying capability (and cost)
- Based on the cable, your service provider can give you different bandwidths
  - E.g. T1 or DS1 = 1.544 Mbps, T3 or DS3 = 44.736 Mbps etc.
- Last mile refers to technologies to connect the “last mile” to your home
  - Plain old telephone service (POTS) - 56 kbps
  - ISDN: 64-128 kbps
  - xDSL: up to 55.2 Mbps
  - Cable: up to 40 Mbps
  - WiMAX or Canopy (http://canopy.nd.edu/) for wireless access

Cellular and wireless

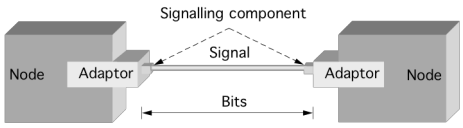
- Wireless Local Area Networks (WLAN): IEEE 802.11a operates in 5 Ghz at 54 Mbps, 802.11b operates in 2.4 GHz at 11 Mbps, 802.11g operates in 2.4 GHz at 54 Mbps
- Bluetooth wireless, infrared (irda) for short distance
- Cellular: described by generations
  - Advanced Mobile Phone System (AMPS) - 1G - Analog
  - Digital - 2G - PCS, GSM (kbps) …
  - 2.5 G - EDGE (up to 128 kbps)
  - 3G - IMT 2000 (up to 2 mbps)
  - 4G …

Take away message

- These hardware technologies create a virtual "wire". Next we need to figure out how to send information on this "wire"

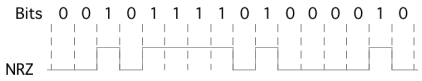
Encoding

- How do we encode the binary data from higher layers for transmission from one node to the next
  - Suppose I want to send 1010101, how do they appear on the wire?



Non-return to zero (NRZ)

- Send 1's by a high signal and 0's by a low signal



- Problems:
  - Baseline wander: The receiver averages signals to identify 1s and 0's. Too many ones or zeros in the data affects this averaging - its difficult to detect too many 1's or 0's because of noise
  - Clock recovery: both sender and receiver use clocks to know when a new bit starts. When there is a change from 1 to 0, we know there is a clock change. Too many 1's or 0's - we lose clock synchronization

Non-return to zero inverted (NRZI)

- Transition from current signal to encode 0, stay in current signal for 0
  - Solves consecutive 1's but not 0's
- Manchester encoding: 0 - low to high transition and 1 - high to low transition
  - Doubles signalling rate - 50% efficiency
- 4B/5B: 4 bits of actual data is encoded by 5 bits
  - 5 bits chosen such that no more than one leading 0 and two trailing 0s.
  - The resulting 5 bit is transmitted using NRZI
  - 80% efficiency (1 bit wasted for every 4 bits)

Take away message

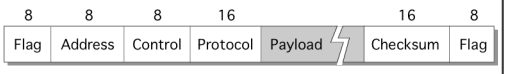
- Encoding introduces inefficiencies because transmitting bits also requires clock synchronization. Lowering efficiency means that you do not get as much raw bandwidth.

Framing

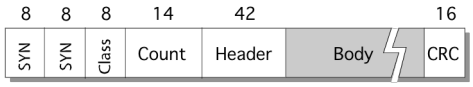
- When we transmit packets, we need to know when the packet begins and ends such that the boundaries can be framed
  - When there are no packet transmissions, the wire still carries nothing which might be interpretted as a 0 or 1 or undefined. For example, in NRZ, sending nothing could mean 0s. Framing allows us to know whether the 0s are part of a frame or not

Byte-Oriented Protocols (BISYNC, PPP)

- Sentinel approach
  - Add special bytes/characters at the beginning and end of frame.
    - If this special byte happens inside the frame, it has to be escaped using a process called character stuffing.
      - For example, in C, \ character escapes the next character as in \n, \t etc. To print \ itself, you need to enter \\
  - E.g. PPP (you might have heard of it through dialup accounts or cable internet as PPPOE (PPP over Ethernet). Flag = 011111110



- Byte-Counting approach
  - Enter the frame size at the beginning
  - What if this number is corrupted - framing error
    - Suppose instead of receiving 10 (the correct number), you receive the count as 100. This error can subsume subsequent frames upto the next 90 extra bytes
    - Use SYN to synchronize after such an eeror



Bit-Oriented Protocols

- Assumes that frames are made up of just bits (8 bits = byte)
- Bit stuffing to get around bit sequences that make up the frame bit sequences
- Size of frame depends on contents (because if stuffing)

Clock based framing

- SONET - Synchronous Optical Network
  - Send the sync header every so often. The payload is not stuffed as the clock between sender and receiver are synchronized by the sync headers.