ECE 435 – Network Engineering
Lecture 25

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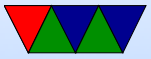
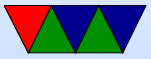
Announcements

- HW#9 was posted
- Responded to project topics

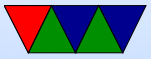


The Last Mile (to your House)



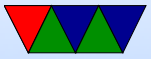
Wired Phone Network

- Originally all analog. Point-to-point
- Switching offices, operator manually jumper
- Later automatic dialing involved (tell anecdote on Stowager gear)
- Wires connecting to your house "local loop"
- Anything much beyond local exchange "long distance", cost more money
- Different rates at night than day

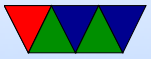


Data over Phone lines

- Rent your own local loop
- Modems on both ends. Before 1984 not allowed to, acoustic couplers (WarGames)
- Modem doesn't send raw binary, it uses sine wave carrier Max a perfect phone line can do about 3000Hz, so max is 2400bps. Instead change the "baud" which is *symbols* per second. Say four different voltages. Also say different phase shifts. Quadrature Phase Shift Keying

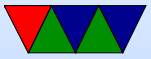


- Interesting to me as I used to do all of this
- Duplex – simplex or full duplex
- Hit Shannon limit about 33.6kbps
- how do you hit 56k? need ISP equipment at the exchange, can bypass some restrictions. Also different rates up/down



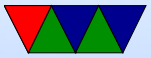
If You Were Rich in POTS days

- ISDN (64kbit? 128kbit?)
- T1-lines (1.5Mbit)



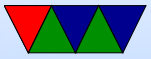
Phone Line Hacking / Security

- 2600, Captain Crunch, Blue boxes



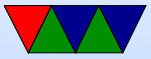
Broadband

- Sort of a generic (marketing?) term meaning “faster than a landline modem”



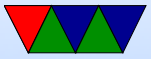
DSL/ADSL

- 1...100Mbps download, 1...1Mbps upload
- Normal phone lines have a filter from 300 – 4000Hz
- For DSL they remove the filter
- You need to put own filter on your actual phones in house
- Speed depends on distance to the facility
- Often asymmetric. Could split 50/50, but people usually download more so make it favor download
- 250 channels of data coming down. Modem has a DSP



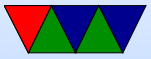
to convert this to data

- Pair bonding (up to 1GBps) by using two pairs (for historical reasons used to get two pairs to your house in case you wanted two numbers)

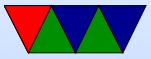


Cable Modems

- Cable typically a broadcast medium
- Single cable shared by many users; download a large file and you slow everyone else (not a problem with DSL)
- Bandwidth of co-ax higher than twisted pair
- TV stations in US typically 54-550MHz
  So for cable modem, uplink in 5-42MHz
  Downlink 550MHz-750MHz
  Asymmetric
- QAM-256, QPSK

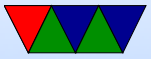


- encrypted
- Originally hundreds of houses per run, but now fiber getting closer and closer and fewer shared resources



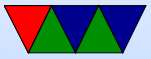
Fiber To Home

- Verizon FIOS and Similar
- Originally 50Mbps. These days 500Mbps, 1Gbps, 2Gbps, symmetric
- VOIP



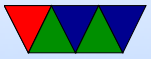
Other

- Cellphone based
- Satellite / Starlink



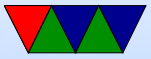
Data Link Layer

- All about frames.
- Transmitting values to nearby machines
  - ones/zeros go out to physical layer
  - same bits arrive back on other machine



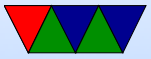
Link Layer – Issues

- Addressing – specify source/destination
- Framing – split data into frames
- Error control and reliability
- Flow Control – stop from sending too fast
- Medium Access Control – method to decide which host gets to transmit (handle collisions)



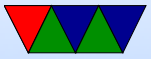
Framing

- Break up data stream into frames, checksum each on send and receive
- How do you break up into frames? (Delimiting)
  1. Character count – send a byte describing how many chars follow, followed by that many chars
     Trouble is, what if count affected by noise. Then the data gets out of sync, no way to resync
  2. Flag bytes – special byte indicates start and stop, you can then use to find frame boundaries



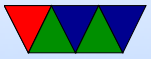
What to do if flag byte appears in data you are sending? Use escape chars (sometimes called "byte stuffing"?)

3. Bitstuffing – instead of sending multiples of 8 bits, send arbitrary bit widths, with special bit patterns as flags
4. Physical layer coding – for example, 4B/5B coding where 4 bits is represented by 5 bits and the extra combinations can be used as frame markers and for error checking



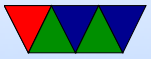
Frame Format

- Frame and Packet sometimes used interchangeably
- Usually a header, with address, length, type, error detection
- Followed by data
- Might be trailer at end



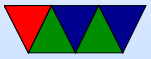
Addressing

- How do you determine which machines gets data?
- How do you know who to respond to?
- Global or local? Only few extra bits of extra overhead so often global these days (MAC address?) IEEE 802 is 48-bits. Is that enough?

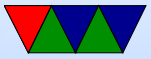


Flow Control

- What if sender tries to send faster than receiver can handle?
- Feedback based: receiver sends back info saying it is ready for more
  - Serial example
  - Hardware flow control: extra wires to indicate need to slow down
  - Software flow control: control-S or control-Q in stream, need to escape



- Rate-based flow control. The rate is set in the protocol. Not really used in the link layer



Medium Access Control (MAC)

- Whose turn is it to send or receive?
- What if on a shared medium (wire, spectrum)