ECE 435 – Network Engineering
Lecture 4

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Announcements

- Homework 2 was posted late, due next Monday
- Homework 1 grades returned RSN

Solutions for HW1

1. Which layer is bits/frequencies? Physical

2. S/N is 500? 10log500 = 27dB

3. 100MHz, 14dB, Shannon? (typical numbers for cat5 twisted pair)
   bps $= Hlog_2(1 + \frac{S}{N})$
   S/N = 25
   bps $= 100M * log_2(1 + 25) = 470Mb/s$

4. Benefits of fiber over copper:

(a) thin, lightweight
(b) fewer repeaters
(c) no corrosion
(d) no power surges

Notes for HW2

- Low-level Linux/UNIX programming
- Sort of ancient
- socket() system call. Returns a file descriptor.
- Can you write to it right away? Need to configure first.
- Server
  - Port to listen on. 16-bit. Above 1024. htons (why?)
  - bind() system call to bind to port
  - listen() system call says we want to listen and sets up a queue of incoming connections

- accept() waits for an incoming connection, and creates a file descriptor for each one
- then you can use the read/write system calls to talk over the connection, like with a file

- Client
  - look up the address of the server with gethostbyname(). In the hw we are just using "localhost" which probably maps to 127.0.0.1
  - setup data structure with address/port info
  - connect() system call used to connect
  - just read/write to original socket_fd

- Now you have enough to do networking! Write a web server! Online video game! etc. You'll find it does get more complicated.
- tcpdump

Coding

- Source Coding – reduce data needed to be send. Compression (JPEG, MPEG, audio, etc)
  lossy, lossless, discuss kinds

- Channel Coding – protect data through noisy medium, adds extra info. error correcting code, hamming codes, reed-solomon codes, turbo codes

- Line Coding – pulse modulation (PCM) to transmit binary signal

- PAM (pulse-amplitude modulation)
- PWM (pulse-width modulation)
- PCM (pulse-code modulation)
- PWM/PDM (pulse-width/duration modulation)

- PCM most popular because easier to pick on/off then to measure time or amplitude

- self-synchronization

Line Coding

- self-synchronization. Need to keep transmitter and receiver synchronized (why?) how, usually a certain number of 0/1 transitions, can resync on those
- signal-to-data ratio (SDR). data rate is number of data bits sent in second, signal rate is number of signal elements in a second (baud)
- unipolar signaling: 1 is positive voltage, 0 is ground
- polar signaling: 1 is positive volt, negative is negative

volt

- bipolar 1 is positive or negative volt, 0 is ground
- unipolar require more power, DC-unbalanced, not used much
- NRZ (non return to zero, return to zero mid-bit)
- NRZ-L (level) positive for 1, negative for 0
- NRZ-S (space) 1 means no change in signal, 0 means transition

- HLDC and USB are non-return-to-zero-space (NRZ-S) long strings of zeros (synchronization?) disks use RLL (coded to at least so many transitions), USB uses bit-stuffing (inserting extra bits)

- PRZ return to zero returns to zero halfway through bit. synchronized but at expense of half of bandwidth

- Manchester encoding

- AMI, alternate mark inversion, pseudoternary

Block Coding

- a smaller chunk of bits encoded with larger,
- 4B/5B: i.e. user 5B to encode 4B. Then if something goes wrong can no, also can send control info along. also can ensure that when grouped together the pattern has no more than three consecutive zeros
- 8B/10B widely used. PCI Express, firewire, serial ATA, DVI/HDMI, gigabit Ethernet. same number of 0s/1s for a data stream (charge building up?) maximum run

length

Modulation

- passband modulation. Convert digital signal to analog, then multiple by much higher carrier frequency.

- ASK amplitude shift keying
  usually two levels of amplitude, one for 0 one for 1

- FSK frequency shift keying – two distinct frequencies
  bandwidth concerns

- PSK phase shift keying – two phases, 0degree for 0 and 180deg for 1

- ASK is limited by noise (reduces amplification). FSK needs two freq, more complex. PSK considered better.
- QPSK (four phases)
- Differential phase shift keying (DPSK)
- QAM hybrid quadrature amplitude modulation – amplitude *and* phase

Multiplexing

- Most of the cost of a line is digging the cable. So avoid at all cost

- FDM (frequency division multiplexing). Multiple channels on same cable. AM radio analogy. 1MHz total bandwidth, but many channels within
  twelve 4kHz channels in 60-108kHz band. Some overlap (non-perfect filters) so noise can escape
  1G cellphone

- WDM (Wavelength division multiplexing) fiber – basically multiple colors down same fiber

- TDM (time division multiplexing)
  FDM is analog.
  T1 line – 1.544Mbps. PCM, 8-bit at 8000Hz (why?)
  24 channels, round robin
  56kbps (7bits*8Hz) plus 1 bit control
  GSM cellphone

- SS spread spectrum – spread across frequency band. pseudo-noise, barker and willard codes. harder to jam

3G cell phone

- DSSS (direct sequence SS)
  802.11b/g/n

- FHSS (frequency hopping SS) – hop among different frequencies, so if one blocked still eventually get through. best for short bursts, hard to synchronize when high-speed transmissions
  bluetooth

- SM (spatial multiplexing)
  802.11n, LTE, WiMAX

- STC (space time coding)
  802.11n,LTE,WiMAX

TDM encoding Tricks

- Differential pulse code modulation – trying to reduce bits. Assume amplitude not going to change more than +/-16 so only include difference.
- Four T1 lines into T2 line (6.312 Mbps)
- Seven T2 lines into T3 line (44.7 Mbps)
- Six T3 lines into T4 line (274 Mbps)