EECS 122, Lecture 5

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Where we are now...

- Notions of network design
- Internet naming and addressing
- Internet service model
- But, how to transfer actual data?

Problem Set

- P & D Chapter 3 (except 3.5)
- Problem Set #2
  - Due 2/11/99
  - 2, 3, 7, 8, 10, 21, 22, 23

Issues in Link Networks

- Encoding (bit representation)
- Framing (and addressing)
- Error detection (& reliability...)
- Media access control (MAC)

Nodes

- Nodes: processor, memory, network intf
  - processors improve ~2x each 18 months
  - memory improves 7% per year
- Lessons
  - processor cache may not help much
  - avoid copying data

Links

- Simultaneous use?
  - Depends on mod (TDM/FDM...)
  - MAC (sharing) protocols
- Data rate, distance, reliability
- Half or Full Duplex operation

Common Media

- Cat 3 UTP (10Mb/s, 100m)
- Cat 5 UTP (100 Mb/s, 100m)
- Mulimode fiber (100 Mb/s, 2km)
- Single mode fiber (2Gb/s, 40km)

Common Telco Circuits

- ISDN (2x64 Kb/s)
- T1 (1.544 Mb/s)
- T3 (44.736 Mb/s)
- OC3 (155.521 Mb/s) [book wrong!]
- OC12 (622.080 Mb/s)
- OC48 (2.48832 Gb/s)

Encodings

- Digital data, digital signals
  - how to represent bits (codes)
- Analog data, digital signals
  - how to represent voltages (sampling)
- Digital data, analog signals
  - how to represent bits (modulation)
- Analog data, analog signals
  - how to represent voltages (modulation)

Digital/Digital Encodings

- Issues in comparing various techniques:
  - signal spectrum
    - high freq->big bw, no dc->better isolation
  - signal synchronization capability
  - signal error detecting capability
  - signal interference and noise immunity
  - cost and complexity

NRZ and NRZI Encoding

- NRZ: non return to zero
  - simple high/low voltage transmissions
  - biggest problem is dc component and lack of easy clock recovery
- NRZI: inverted NRZ
  - ‘stay [0]/transition [1]’ coding
  - (1’s generate square wave, 0’s are flat)
  - differential code (adjacent transitions)
  - better noise immunity

Biphase Encodings

- Manchester, biphase-{M,S}, Differential Manchester
- All require at least 1 transition per bit time. Benefits:
  - synchonization (“self-clocking codes”)
  - no DC component
  - error detection

Manchester

- low-to-high is 0, high-to-low is 1
- bit rate is half the baud rate (50% efficiency)
- used on 10 Mb/s Ethernet

4B/5B Code

- insert extra bits to break up runs
- 4-bit values sent as 5-bit codeword
- codewords have <2 leading 0 & <3 trailing 0; 16 of 32 used (others for ctrl)
- transmitted using NRZI
- 80% efficiency
- used by FDDI & 100Mb/s Ethernet

Analog/Digital Encodings

- Telephony and multimedia systems
- Analog-to-digital (A/D) conversion -> digitization or sampling (codec)
- Pulse Amplitude Modulation (PAM) and Pulse Code Modulation (PCM)
  - represent voltage levels
- Delta Modulation (DM)
  - represent signal derivative

Pulse Code Modulation

- Note that Nyquist gave a sampling rate, but with infinite precision! (PAM)
- PCM: *quantize* analog value to number
  - approximate PAM pulses by n-bit value
  - approximation introduces *quantization noise*
  - S/N = (6n - a) dB [0<a<1] (1bit->6dB gain)

Nonlinear Encoding

- Special representation of PCM samples (quantization levels not equally spaced)
- The problem: mean absolute error for each sample the same; common lower-amplitude signals more distorted (relatively)=>*nonuniform quantization*
- µ-law encoding (US and Japan)
- A-law encoding (Europe)

Relationship to Compression

- Note that careful encoding could give us compression gain! ("source coding")
- Examples:
  - DPCM, ADPCM (differential & adaptive differential PCM)
  - RL (run-length)
  - CELP (code excited linear prediction)
- We will touch on these later...

Delta Modulation

- less complex, better performance
- continuous staircase function moves up or down 1 unit each sampling time
- Important parameters:
  - delta: size of step change at each bit
  - sampling rate

Analog Signals

- Modulation options
  - amplitude (AM), frequency (FM), phase (PM)
  - "shift keying" for digital values (ASK, FSK, PSK)
- Explore these in you signals class!

Digital Communications

- Serial communications
  - 1-at-a-time sending of signaling elements
  - may be <, =, or > 1 bit/symbol
- Asynchronous vs Synchronous Transmission
  - where does a message/byte/bit begin or end?

Asynchronous Transmission

- Timing is precise for only single word
  - start/stop bits
  - may include parity bit for error detection
  - often uses 7-bit ASCII code
  - used for low data rates (e.g. keyboards)

Synchronous Transmission

- Timing requires stable long-running clock and master clock resynchronization
- Clock provided by separate signal or by data (e.g. Manchester coding)
- May be >20% more efficient than asynchronous transmission for large data blocks

Framing

- Byte-oriented protocols
  - BISYNC (BSC), DDCMP, IMP-IMP, PPP*
  - * common mode
- Bit-oriented protocols
  - HDLC
- "Other"-oriented protocols
  - SONET

Byte-Oriented Protocols

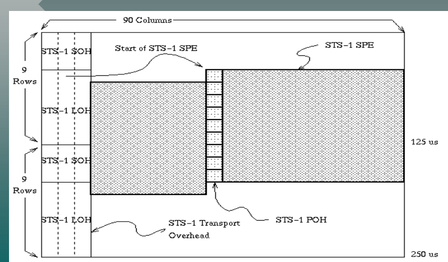
- Sentinel approach
  - look for special control codes in data stream
  - Examples: SYN (synchronize), SOH (start of header), STX (start of text), ETX (end of text)
  - Problem: have to escape occurrences of sentinels (*byte stuffing*)
  - **Frame size is data dependent!**
- Byte-count approach (cnt field errors!?)

Bit-Oriented Protocols

- Treat link as bit (not byte) stream
- HDLC idle pattern 01111110
- Use bit stuffing if 5 consec 1's in data:
  - insert a zero before continuing
  - unstuff at receiver

"Other"-Oriented Protocols

- SONET frame format (telcos)



SONET Facts

- Similar protocol (SDH) in Europe
- Full spec. is very complicated
  - STS-1 frames, 8000 frames/sec
    - 90x9x8000x8 = 51.84 Mb/s
    - 87 useful payload columns -> 50.112Mb/s

SONET/SDH Framing

- First 2 bytes indicate start of STS-1
- Periodic sync bytes each 128 usec
- No bit stuffing, uses periodic sentinels
  - frames sent every 128 usec, "pointer" field indicates start of data; needs good clock
- Data offset "pointer" helps *justification*