CS 337
Winter 2004

Data Link Layer, Part 1

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What we'll cover today

- Physical links
- Encoding (briefly)
- Framing
- Error detection

Definitions

- payload: The actual data in a message
- header: Extra information (routing, etc.) Also called overhead
- multiplexing: Combining more than one signal, stream, etc. onto a single link

Links

- Transmit data as signals (EM waves)
- Encoding data into EM waves:
  - modulation: vary amplitude, frequency, or phase of signal to produce 0s and 1s
  - aggregation of streams:
    - full-duplex: transmit one signal in forward direction and one in reverse direction at the same time
    - half-duplex: signal can only be transmitted in one direction at a time
Types of links

- Local: 10-100 Mbps
  - Ethernet: coax or Cat-5
  - fiber
  - wireless

“Last mile”

- between the edge of your local network and your service provider's network
- POTS (phone line): 56 kbps
- ISDN: ~128 kbps
- xDSL: see next slide
- cable modem: ~40 Mbps
- T1: 1.54 Mbps

xDSL

- High speed over phone lines (“twisted pair”)
- Need to be within 18,000 feet of a “central office”
- Types:
  - ADSL: asymmetric (more BW downstream than upstream)
  - SDSL: symmetric (same BW downstream and upstream)

“Long-haul” links

- Fiber
- Format: OC-n
  - OC = optical circuit
  - n = multiple of 51.84, indicates line BW
- Common types:
  - T1/T3: shorter (local) connections, 1.54 Mbps/44.74 Mbps
  - OC-3: regional connections, 155.25 Mbps
  - OC-12: regional, some backbone, 622.08 Mbps
  - OC-48: backbone (older), 2.49 Gbps
  - OC-192: backbone (newer), 10 Gbps
  - OC-768: new/experimental, within data centers, 40 Gbps
Converting data to signals

- Typically, we encode 0 as “low” signal and 1 as “high” signal
  - NRZ encoding
- Problems:
  - how do we detect “low” from “high”? (threshold)
  - consecutive 0s or 1s
    - Receiver calculates threshold based on average of signals it has received; stretches of 1s or 0s can throw off this average (baseline wander)
    - Receiver uses signal to make sure its clock is in sync with the clock of the sender; fewer transitions mean more opportunities for the clocks to get out of sync (clock drift)

Solution: Encoding

- Ensure that there are frequent transitions in the data
  - break up stretches of 0s or 1s
- Example strategies
  - Manchester encoding (Ethernet): XOR clock with signal
  - 4B/5B (FDDI): table-based code lookup

Next problem

- We can't transmit all the bits at once!
  - packet-switched networks
- Solution: framing
  - defines how to break up the bits into meaningful chunks (“frames”)
  - Frames can be defined by
    - byte boundaries
    - bit boundaries
    - clock boundaries

Byte framing

- Example: PPP
- Sentinel byte framing: begin and end each frame with one or more “marker” bytes
  - character stuffing
- Byte count framing: include the number of bytes in the frame's payload at the beginning of the message
Bit framing

- Example: Ethernet, HDLC
- Similar to byte framing
- Sentinel-based
- May need to do *bit stuffing*
- Non-uniform frame sizes