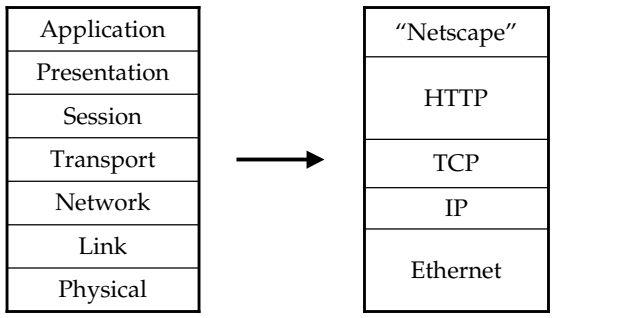
CSE/EE 461 – Lecture 3

Links and Frames

David Wetherall
djw@cs.washington.edu

Last Time …

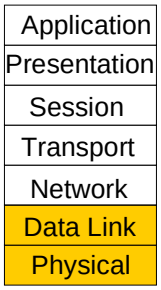
- Protocols, layering and reference models



The OSI Model Sample Protocol Stack

This Lecture

- The physical/link layers:
  - Different kinds of media
  - Model of a link
  - Framing messages
- Focus: How do we send a message across a wire?

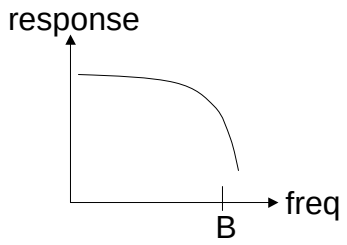


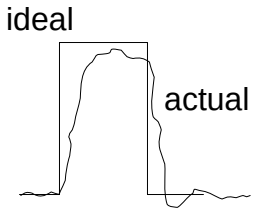
1. Different kinds of media

- Wire
  - Twisted pair, e.g., CAT5 UTP, 10 → 100Mbps, 100m
  - Coaxial cable, e.g, thin-net, 10 → 100Mbps, 200m
- Fiber
  - Multi-mode, 100Mbps, 2km
  - Single mode, 100 → 2400 Mbps, 40km
- Wireless
  - Infra-red, e.g., IRDA, ~1Mbps
  - RF, e.g., 802.11 wireless LANs, Bluetooth (2.4GHz)
  - Microwave, satellite, cell phones, …

Wires

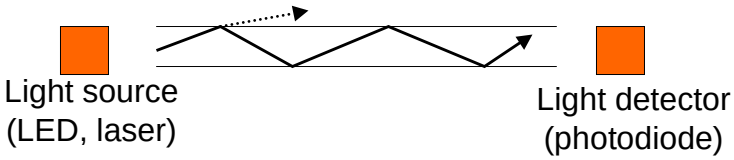
- Signal subject to:
  - Attenuation (repeaters)
  - Distortion (frequency and delay)
  - Noise (thermal, crosstalk, impulse)





Fiber

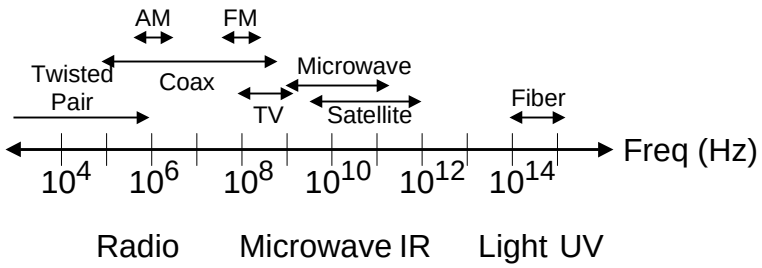
- Long, thin, pure strand of glass
  - Enormous bandwidth available (terabits)



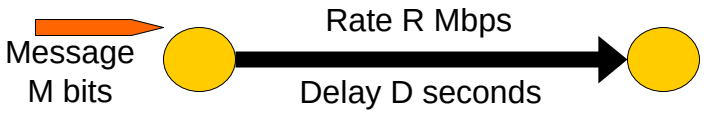
- Multi-mode allows many different paths, dispersion
- Chromatic dispersion if multiple frequencies

Wireless

- Different frequencies have different properties
- Signals subject to atmospheric/environmental effects



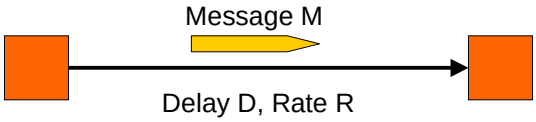
2. Model of a Link



- Abstract model is typically all we will need
  - What goes in comes out altered by the model
- Other parameters that are sometimes relevant
  - The kind and frequency of errors
  - Whether the media is broadcast or not

Message Latency

- How long does it take to send a message?



- Two terms:
  - Propagation delay = distance / speed of light in media
  - Transmission delay = message (bits) / rate (bps)
- In effect, slow links stretch bits out in time/space
- Later we will see queuing delay …

One-way Latency examples

- Either a slow link or long wire makes for large latency
- Dialup with a modem:
  - D = 10ms (say), R = 56Kbps, M = 1000 bytes
  - Latency = 10ms + (1024 x 8)/(56 x 1024) sec = 153ms!
- Cross-country with T3 (45Mbps) line:
  - D = 50ms, R = 45Mbps, M = 1000 bytes
  - Latency = 50ms + (1024 x 8) / (45 x 1000000) sec = 50ms!

Terminology

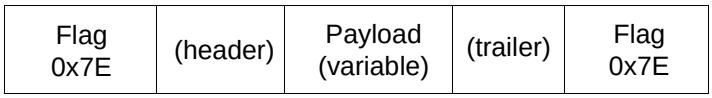
- Latency is typically the one way delay over a link
  - But latency and delay are generic terms
- The round trip time (RTT) is twice the one way delay
  - Measure of how long to signal and get a response
- An important metric is the bandwidth-delay product
  - Measure of how much data can be in-flight at a time

3. Framing

- Need to send message, not just bits
  - Requires that we synchronize on the start of message reception at the far end of the link
  - Complete Link layer messages are called frames
- Common approach: Sentinels
  - Look for special control code that marks start of frame
  - And escape or "stuff" this code within the data region

Point-to-Point Protocol (PPP)

- IETF standard, used for dialup and leased lines



- Flag is special and indicates start/end of frame
- Occurrences of flag inside payload must be "stuffed"
  - Replace 0x7E with 0x7D, 0x5E
  - Replace 0x7D with 0x7D, 0x5D

Alternatives that avoid stuffing

- "Invalid" signal from physical layer
  - Just trust me. Used in Ethernet and FDDI (later).
- Explicit byte count after flag
- SONET: "clock"-based framing
  - Periodic sync information plus very accurate clock
  - Used extensively in the telecommunications industry

- What are the pros and cons?
  - Efficiency (in terms of bandwidth)
  - Robustness (with respect to errors)

Key Concepts

- We typically model links in terms of bandwidth and delay, from which we can calculate message latency
- Different media have different properties that affect their performance as links
- Framing allows complete messages to be recovered at the far end of the link