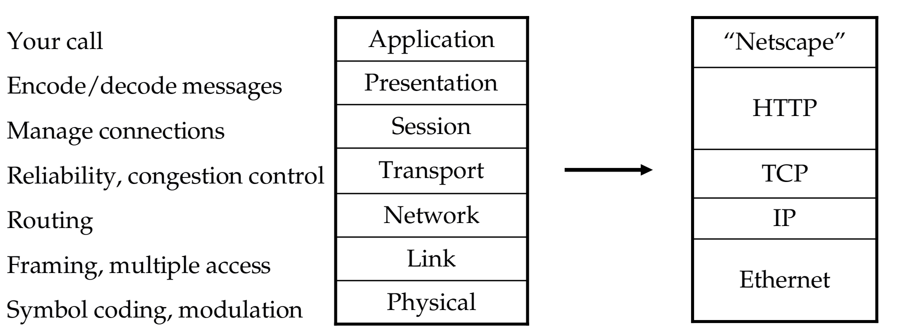
CSE/EE 461 – Lecture 3

Bits and Bandwidth

Last Time …

- Protocols, layering and reference models



The OSI Model   Sample Protocol Stack

Ethernet Hdr	IP Hdr	TCP Hdr	HTTP Hdr	Payload (Web object)

What's Inside a Packet

Last byte

Ethernet Header:	FROM=00:30:65:0a:ea:62, TO=00:30:64:9a:11:22, SIZE=200,…	Top (start)
IP Header:	FROM=128.95.1.32, TO=28.2.5.1, SIZE=200-SIZEOF(Ehdr)	
TCP Header:	FROM=Port-5000, TO=Port-80, Byte#=23, SIZE=200-SIZEOF(Ehdr)-SIZEOF(IPHdr)	
HTTP Hdr	HTTP v.1.0, Mosaic,…	
Good Stuff	GET http://netscape.com/news.html	Bottom (end)

A Protocol is an ENCAPSULATION.
One protocol's *payload* may be another encapsulated protocol.

L3.3

This Lecture

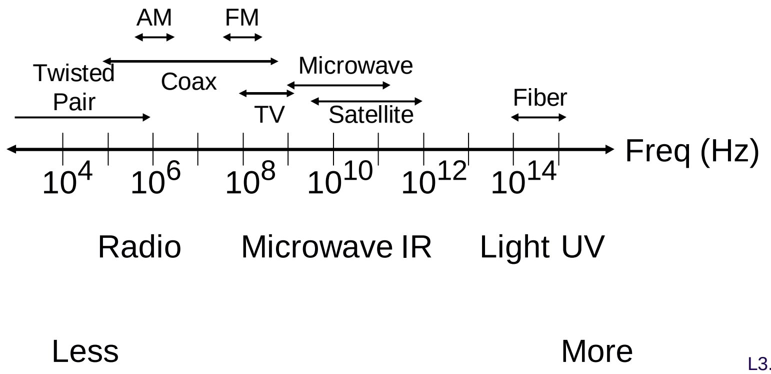
- Focus: *How do we send a message across a wire?*
- The physical/link layers:
  1. Different kinds of media
  2. Encoding bits
  3. Model of a link

Application
Presentation
Session
Transport
Network
Data Link
Physical

L3.4

1. It's all just a wire.

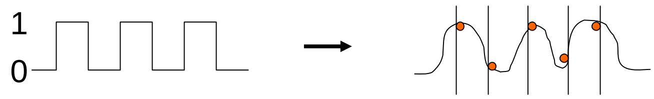
- Different wires have different BW, Reliability, Distance, Power, etc properties.
  - Some wires aren't even wires.



L3.5

2. Bits and Signals

- Wires carry waves.
- Protocols need bits.
- Generate analog waveform (e.g., voltage) from digital data at transmitter and sample to recover at receiver



- We send/recover symbols that are mapped to bits
  - Signal transition rate = baud rate, versus bit rate
- This is baseband transmission … learn more in a signals course
- Various encoding schemes to reduce errors
  - NRZ, NRZI, Manchester, 4B/5B, etc.
  - Goals are:
    - Make transitions clear
    - Don't use too many signals for things other than data

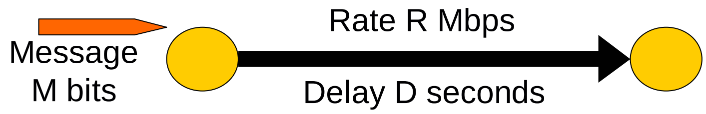
L3.6

… [FRAMING] … [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 <u>frames</u>
- Common approach: Sentinels
  - Look for special control code that marks start of frame
  - And escape or “stuff” this code within the data region

L3.7

3. Model of a Link

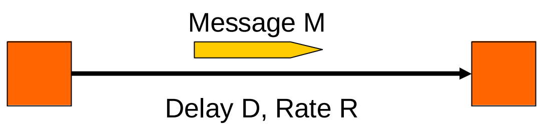


- Abstract model is typically all we will need
  - What goes in comes out altered by the model
- Other parameters that are important:
  - The kind and frequency of errors
  - Whether the media is broadcast or not

L3.8

Message Latency

- How long does it take to send a message?



- Two terms:
  - Propagation delay = distance / speed of light in media
    - How quickly a message the wire
  - Transmission delay = message (bits) / rate (bps)
    - How quickly you can inject the message onto the wire
- Later we will see queuing delay …

L3.9

Relationships

- Latency = Propagation + Transmit + Queue
- Propagation Delay = Distance/SpeedOfLight
- Transmit Time = MessageSize/Bandwidth

L3.10

One-way Latency

- Dialup with a modem:
  - D = 10ms, 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!

- Either a slow link or long wire makes for large latency
- How does latency impact protocol design?

L3.11

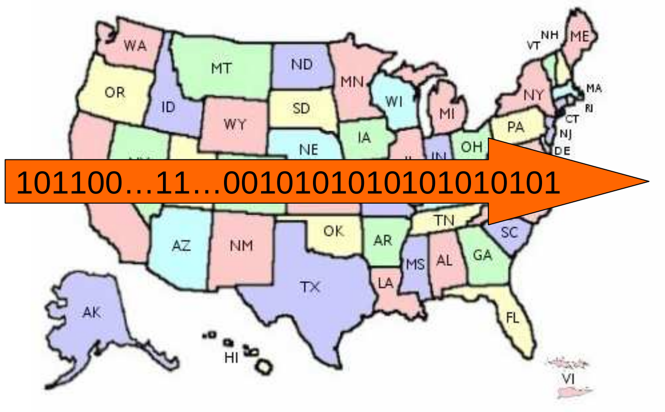
Messages Occupy "Space" On the Wire

- Consider a 1b/s network.
- How much *space* does 1 byte take?
- Suppose delay is 16 seconds.
- How many bits can the network "store"
- This is the BANDWIDTH-DELAY product
  - Measure of "data in flight."
  - 1b/s * 16s = 16b
- Tells us how much data can be sent before a receiver sees any of it.
- Twice B.D. tells us how much data we could send before hearing back from the receiver something related to the first bit sent.
  - Implications?

L3.12

A More Realistic Example

BD = 50ms * 45Mbps = 2.25 * 10^6 = 280KB



L3.13

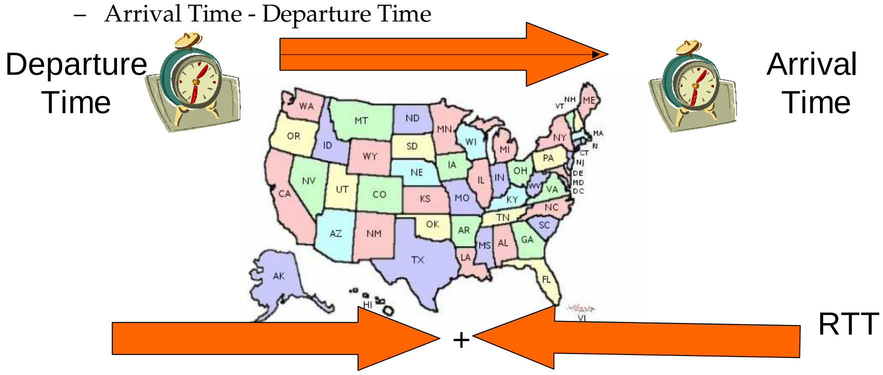
Throughput

- Measure of system's ability to "pump out" data
- NOT the same as bandwidth
- Throughput = Transfer Size / Transfer Time
  - Eg, "I transferred 1000 bytes in 1 second on a 100Mb/s link"
    - BW?
    - Throughput?
- Transfer Time = SUM OF
  - Time to get started shipping the bits
  - Time to ship the bits
  - Time to get stopped shipping the bits
- What's the best we can do to "get started?"
  - Put something, get something
- Always more efficient to move big things

L3.14

Latency and RTT

- Latency is typically the one way delay over a link
  - Arrival Time - Departure Time



- The round trip time (RTT) is twice the one way delay
  - Measure of how long to signal and get a response

Key Concepts

- We need to encode bits into signals so that we can recover them at the other end of the channel.
- 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