Lecture 21: Links and Signaling

CSE 123: Computer Networks

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HW 3 due Wed 3/15

UCSDCSE

Lecture 21 Overview

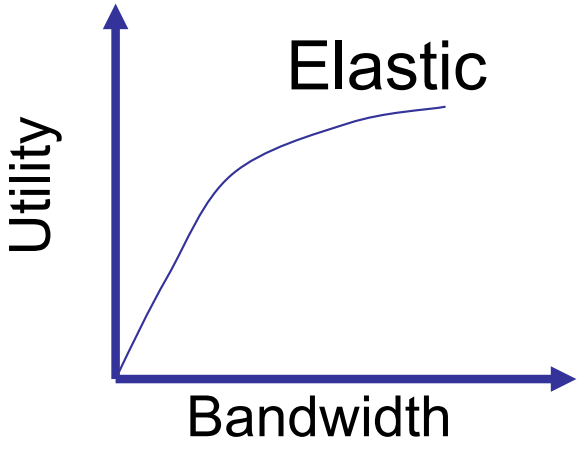
- Quality of Service
- Signaling
  - Channel characteristics
  - Types of physical media
- Modulation
  - Narrowband vs. Broadband
  - Encoding schemes
- A lot of this material is not in the book
  - Caveat: I am not an EE Professor

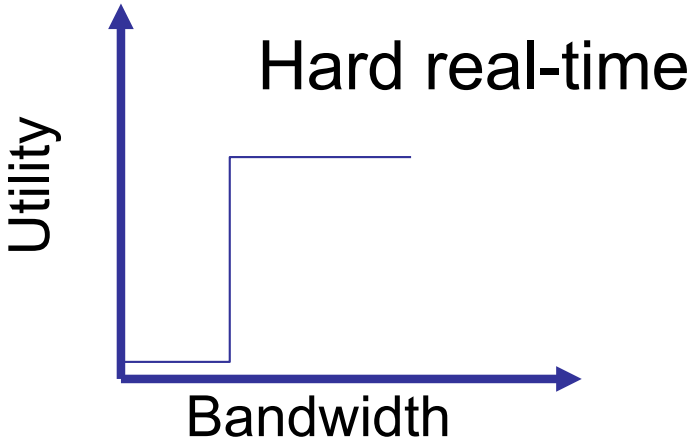
Quality of Service (QoS)

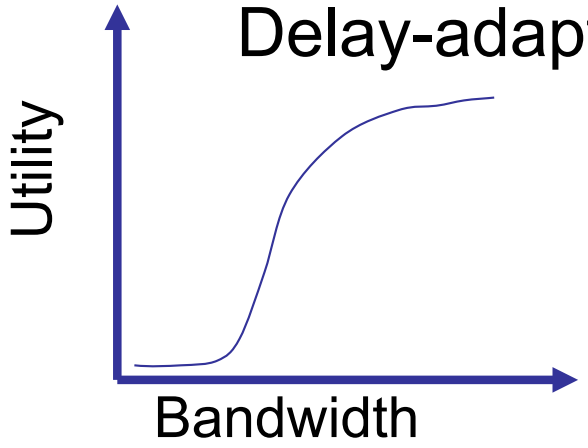
- So far, we have assumed all traffic is equal and provided best effort delivery
  - Perhaps with enforcement to throttle non-responsive senders

- Not always best model. Why?
  - Application demands
    - » I want low-delay low-loss for phone service
    - » For backup, I just need bandwidth… don't care about delay
  - Market differentiation
    - » I want to sell better service for more money
  - Bandwidth management
    - » Don't let BitTorrent eat up all UCSD bandwidth

Different Demands







Packet Classification

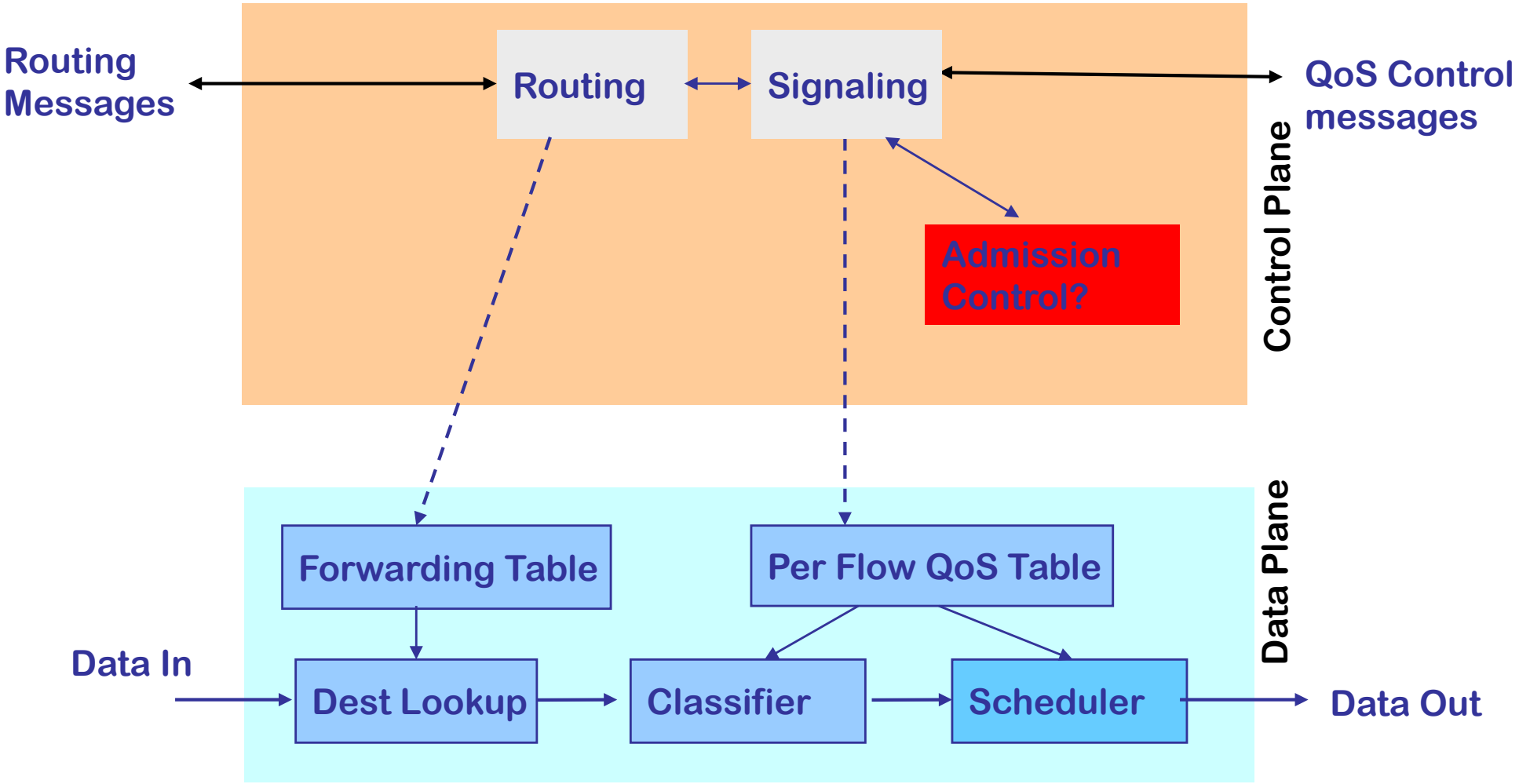
- Want to treat some traffic better/worse than others
  - How to identify the more important traffic?
  - How much better do we want to treat it?
  - How do we actually treat it better?

- Router classifies based on packet header
  - Aggregates
    - » From particular network (IP src address)
    - » For particular protocol (e.g., port 80 traffic)
  - Individual network flows
    - » 5-tuple (src, dst, src port, dst port, protocol)
  - Special header field that indicates traffic "type"

Service Classes

- Best-effort
  - Vanilla IP
- Differentiated service
  - Bronze, Silver, Gold, etc… (effectively priorities, **up to** some amount of bandwidth per time)
  - E.g., best service up to 10Mbps, then best effort
- Predicted service (soft real-time)
  - Network guarantees good performance on average
  - Application *promises* only send as fast as negotiated
- Guaranteed service (hard real-time)
  - Network guarantees good performance always
  - Application promises only send as fast as negotiated

More Complicated Routers



Network-wide QoS

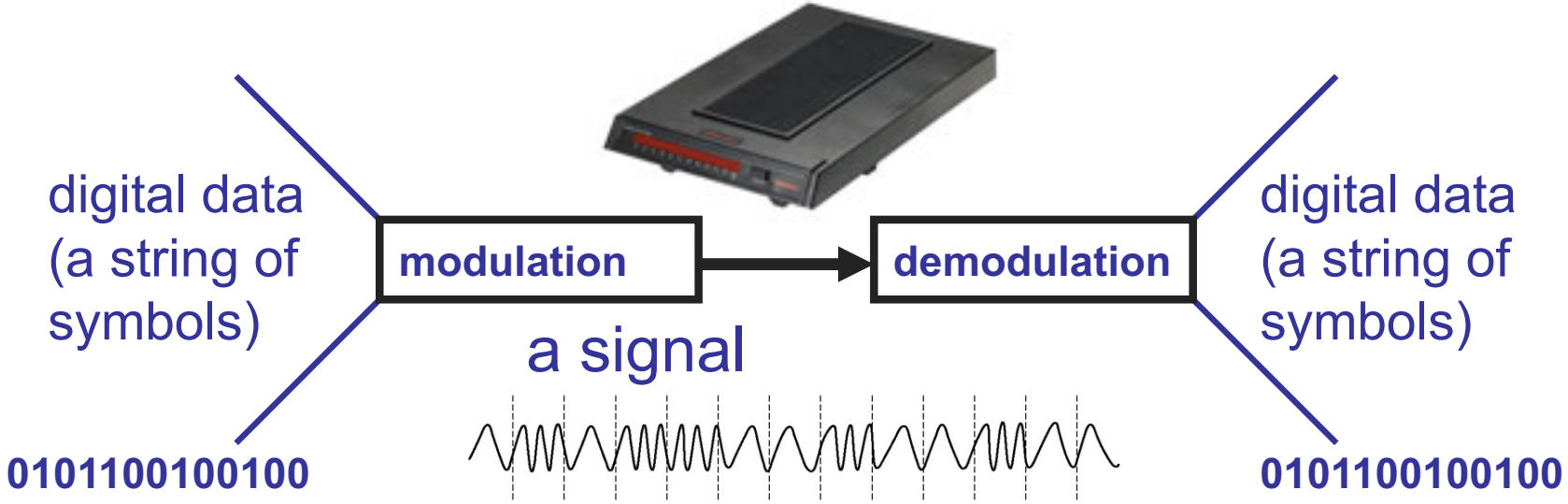
- Integrated services
  - Motivated by need for end-to-end guarantees
  - On-line negotiation of per-flow requirements
  - End-to-end per-router negotiation of resources
  - Complex
- Differentiated services
  - Motivated by economics (multi-tier pricing)
  - No per-flow state
  - Not end-to-end and not guaranteed services
  - Simple

QoS Summary

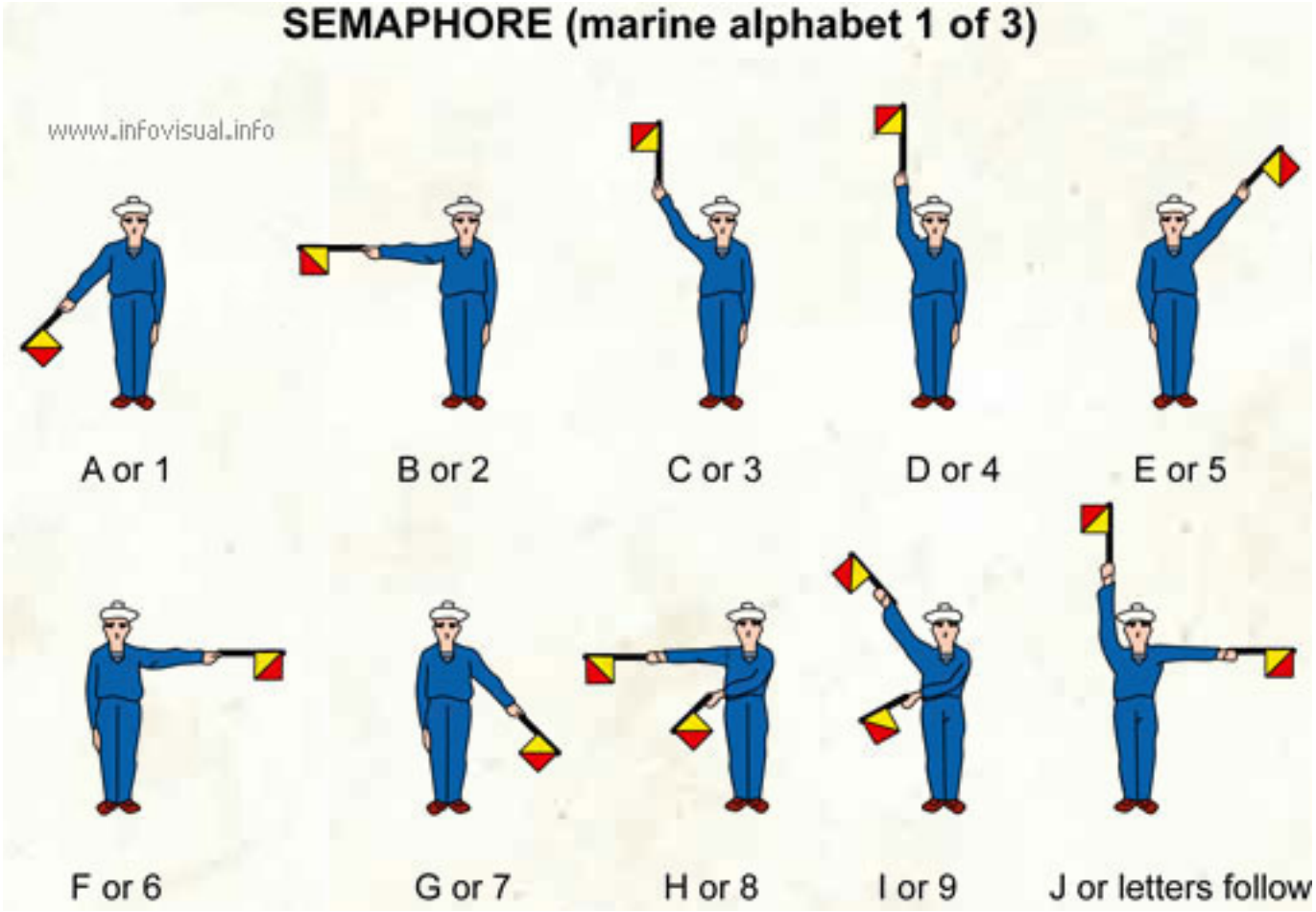
- Routers manage their own resources
  - Buffer management may entail marking/dropping
  - Scheduling discipline determines outgoing packet order
- Token bucket and RED
  - Mechanisms to control traffic flowing through routers
- Networks can provide quality of service
  - Combines per-router traffic policing with network signaling
  - IntServ and DiffServ are contrasting approaches

Underneath it all: Sending bits

- A three-step process
  - Take an input stream of bits (digital data)
  - Modulate some physical media to send data (analog)
  - Demodulate the signal to retrieve bits (digital again)
  - Anybody heard of a modem (Modulator-demodulator)?



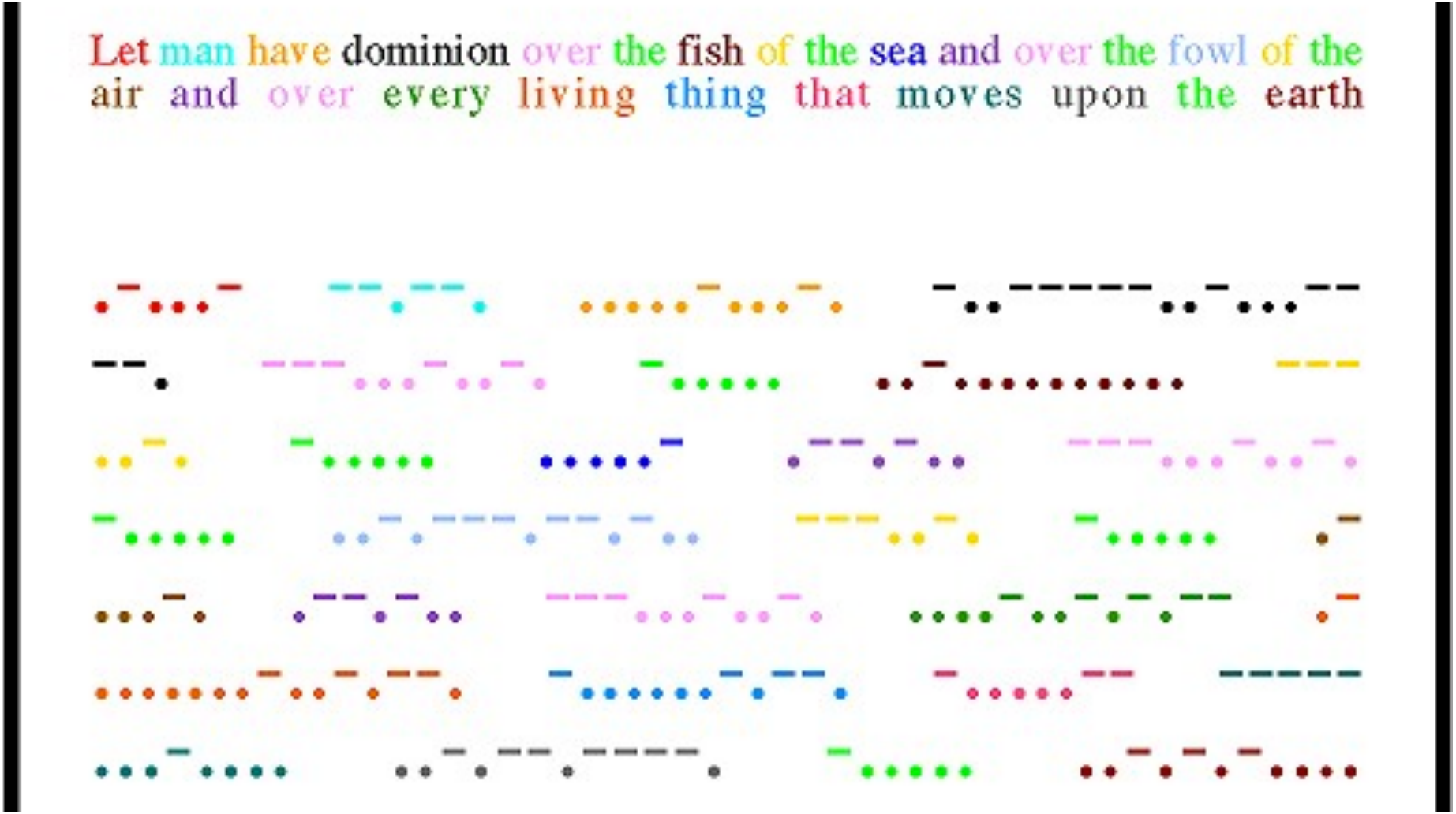
A Simple Signaling System



Morse Code

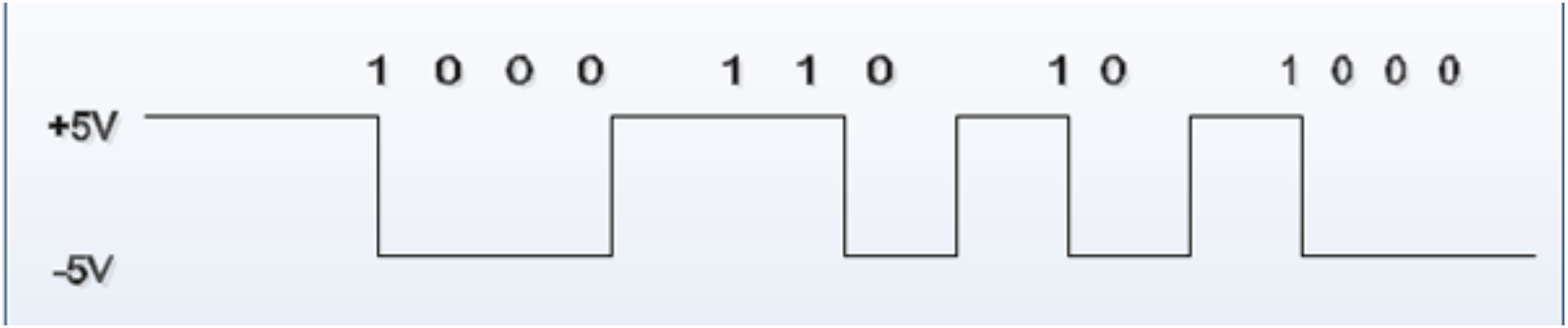
A	·−	V	···−
B	−···	W	·−−
C	−·−·	X	−··−
D	−··	Y	−·−−
E	·	Z	−−··
F	··−·	.	·−·−·−
G	−−·	,	−−··−−
H	····	?	··−−··
I	··	/	−··−·
J	·−−−	@	·−−·−·
K	−·−	1	·−−−−
L	·−··	2	··−−−
M	−−	3	···−−
N	−·	4	····−
O	−−−	5	·····
P	·−−·	6	−····
Q	−−·−	7	−−···
R	·−·	8	−−−··
S	···	9	−−−−·
T	−	0	−−−−−
U	··−		

Morse Code Message



Binary signaling with Voltage

- Encode 1's and 0's on a wire
  - +5 volts = 1
  - -5 volts = 0



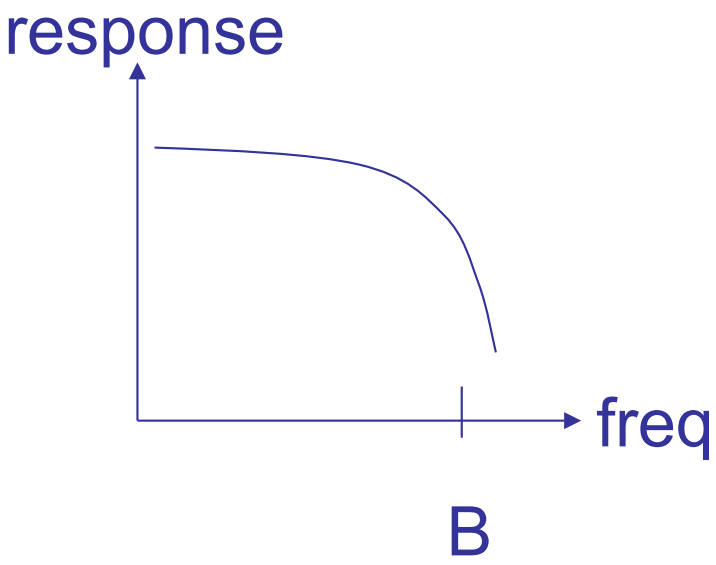
Signals and Channels

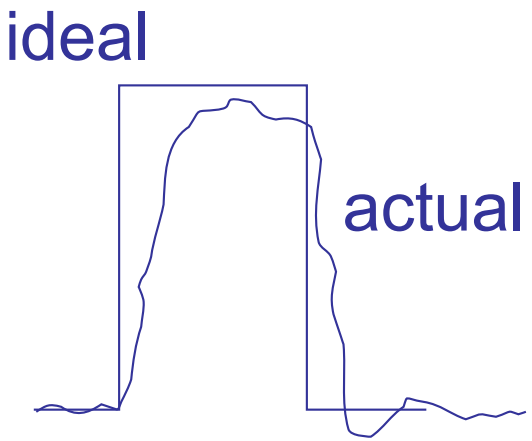
- A signal is some form of energy (light, voltage, etc)
  - Varies with time (on/off, high/low, etc.)
  - Can be continuous or discrete

- A channel is a physical medium that conveys energy
  - Any real channel will distort the input signal as it does so
  - How it distorts the signal depends on the signal

Channel Challenges

- Every channel degrades a signal
  - Distortion impacts how the receiver will interpret signal





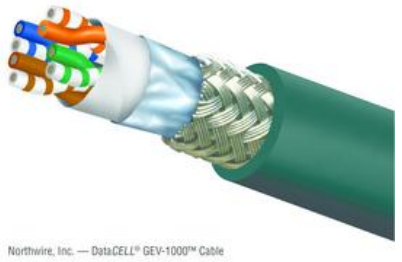
Channel Properties

- Bandwidth-limited
  - Range of frequencies the channel will transmit
  - Means the channel is slow to react to change in signal
- Power attenuates over distance
  - Signal gets softer (harder to “hear”) the further it travels
  - Different frequencies have different response (distortion)
- Background noise or interference
  - May add or subtract from original signal
- Different physical characteristics
  - Point-to-point vs. shared media
  - Very different price points to deploy

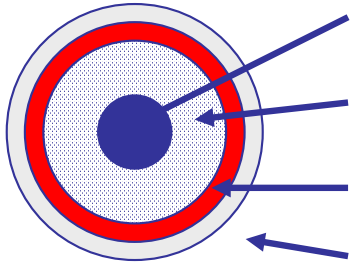
Copper

- Typical examples
  - Category 5/6 Twisted Pair — 10M-10Gbps — 50-100m
  - Coaxial Cable — 10-100Mbps — 200m

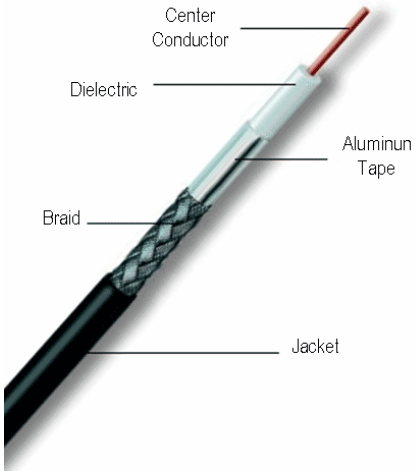
twisted pair



coaxial cable (coax)

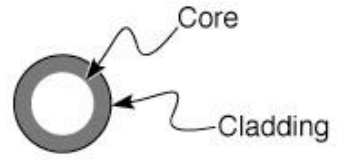


copper core
insulation
braided outer conductor
outer insulation



Fiber Optics

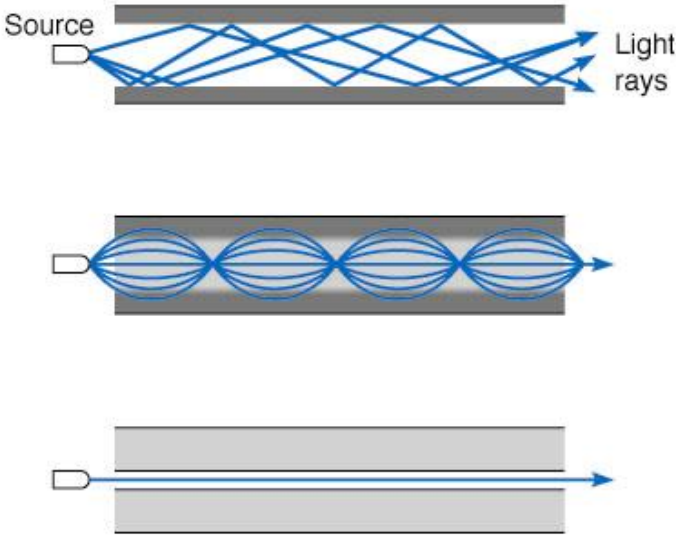
- Typical examples
  - Multimode Fiber 100Mbps-10Gb 500-2000m
  - Single Mode Fiber 1-100Gbps 100m-40km



Step index (multimode)

Graded index (multimode)

Single mode

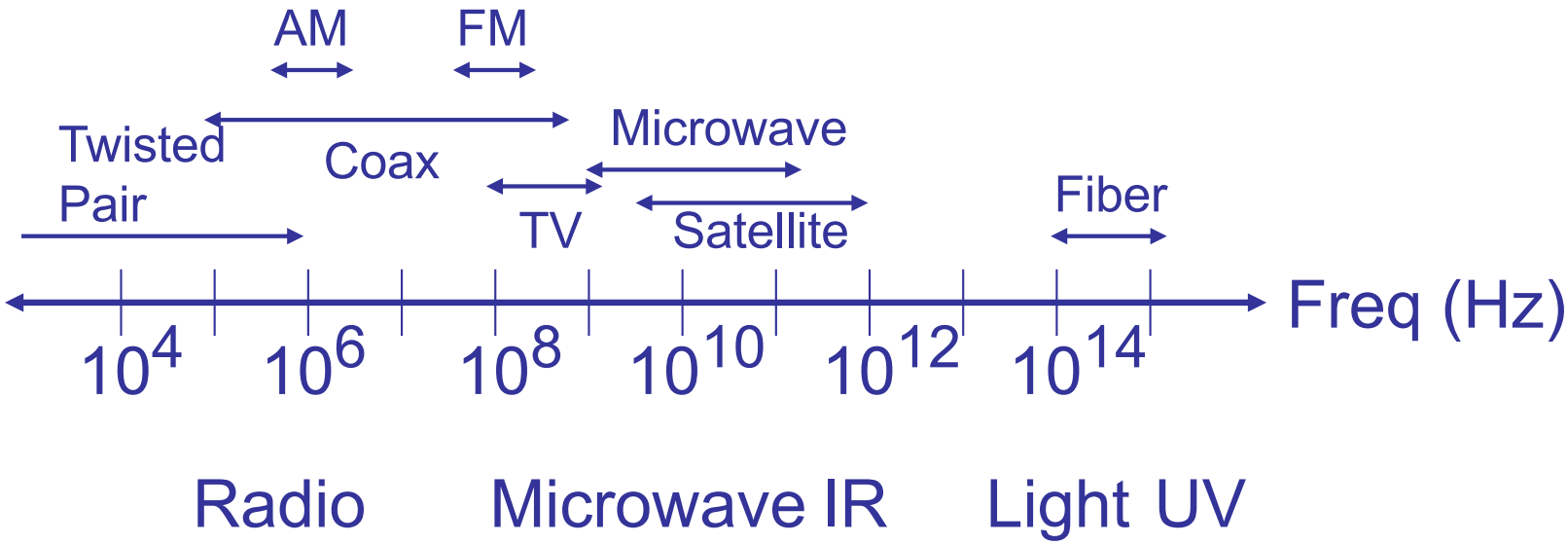


Cheaper to drive (LED vs laser) & terminate

Longer distance (low attenuation)
Higher data rates (low dispersion)

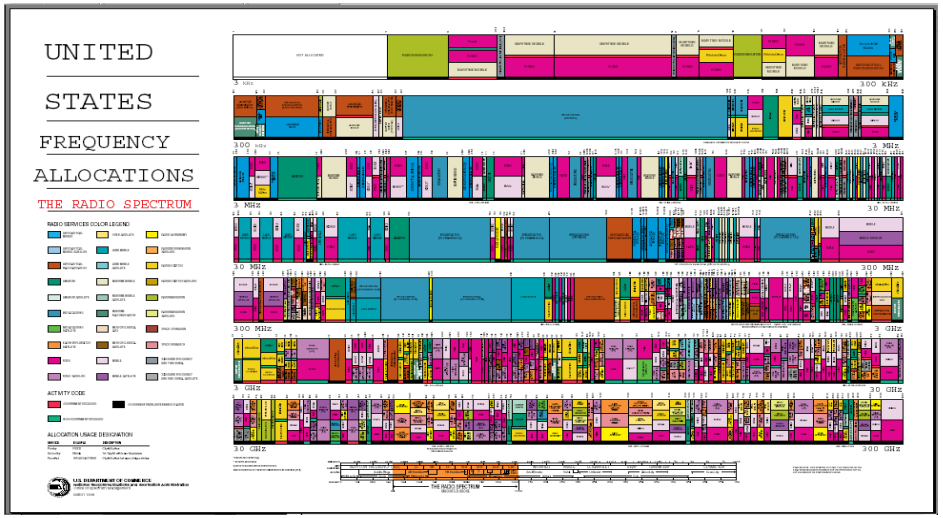
Wireless

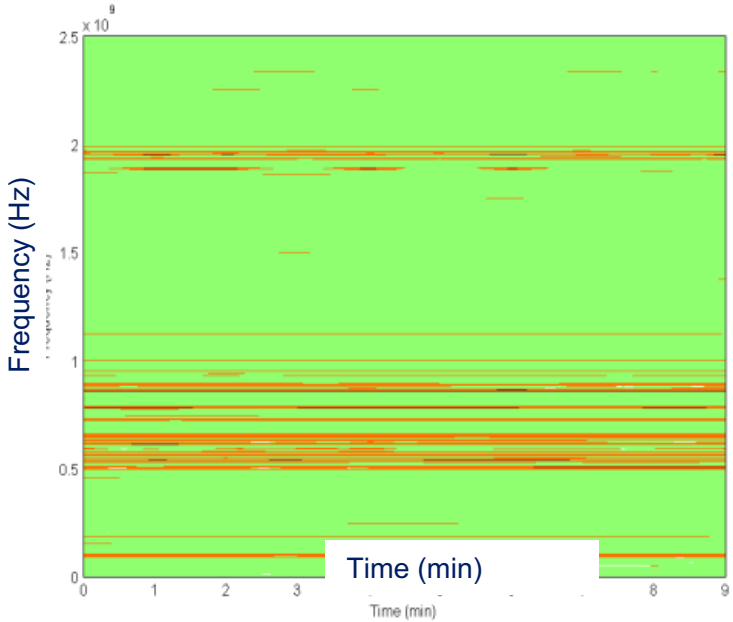
- Widely varying channel bandwidths/distances
- Extremely vulnerable to noise and interference



Spectrum Allocation

- Policy approach forces spectrum to be allocated like a fixed spatial resource (e.g. land, disk space, etc)
- Reality is that spectrum is time and power shared
- Measurements show that fixed allocations are poorly utilized





Hot topic: Whitespace communication

Two Main Tasks

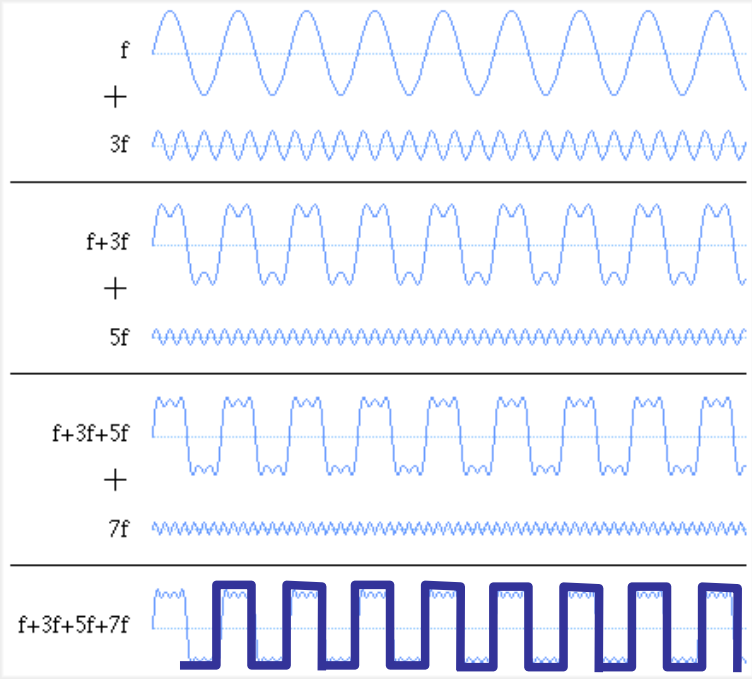
- First we need to transmit a signal
  - Determine how to send the data, and how quickly
- Then we need to receive a (degraded) signal
  - Figure out when someone is sending us bits
  - Determine which bits they are sending
- A lot like a conversation
  - "WhatintheworldamIsaying" – needs punctuation and pacing
  - Helps to know what language I'm speaking

The Magic of Sine Waves

- All periodic signals can be expressed as sine waves
  - Component waves are of different frequencies

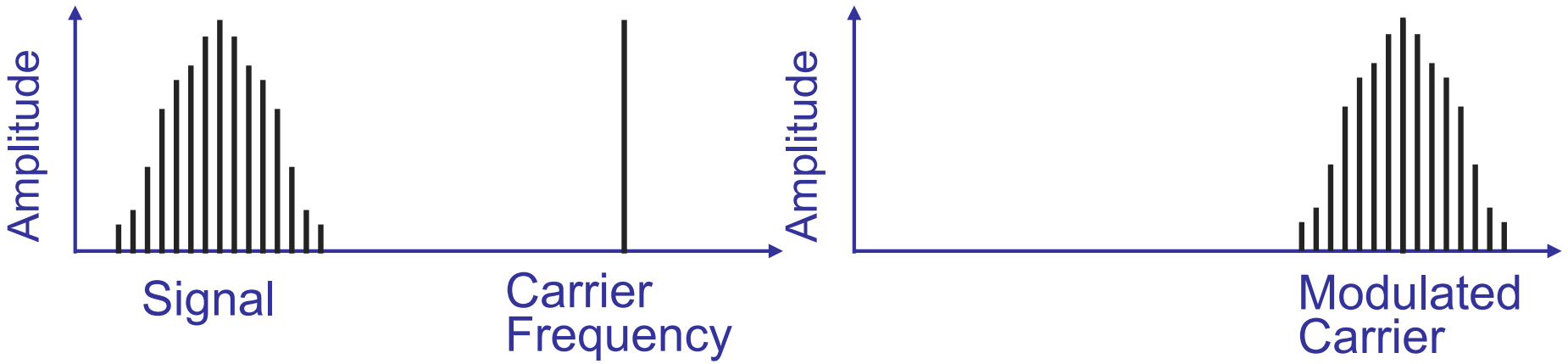
- Sine waves are “nice”
  - Phase shifted or scaled by most channels

- “Easy” to analyze
  - Fourier analysis can tell us how signal changes
  - But not in this class…



Carrier Signals

- Baseband modulation: send the “bare” signal
  - E.g. +5 Volts for 1, -5 Volts for 0
  - All signals fall in the same frequency range
- Broadband modulation
  - Use the signal to modulate a high frequency signal (carrier).
  - Can be viewed as the product of the two signals



For Next Class

- Read 2.2