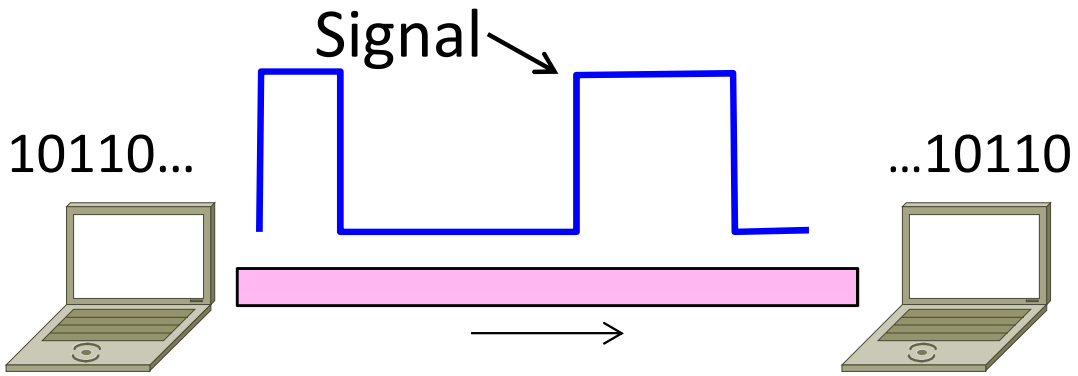
Computer Networks

Signals (§2.2, 2.3)

David Wetherall (djw@uw.edu)
Professor of Computer Science & Engineering
UNIVERSITY of WASHINGTON

Topic

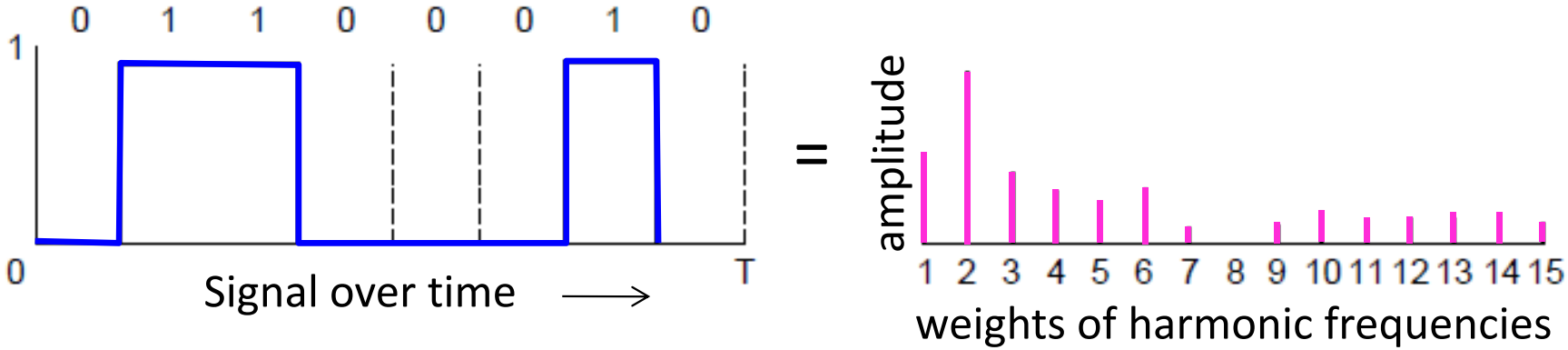
- Analog signals encode digital bits. We want to know what happens as signals propagate over media



Frequency Representation

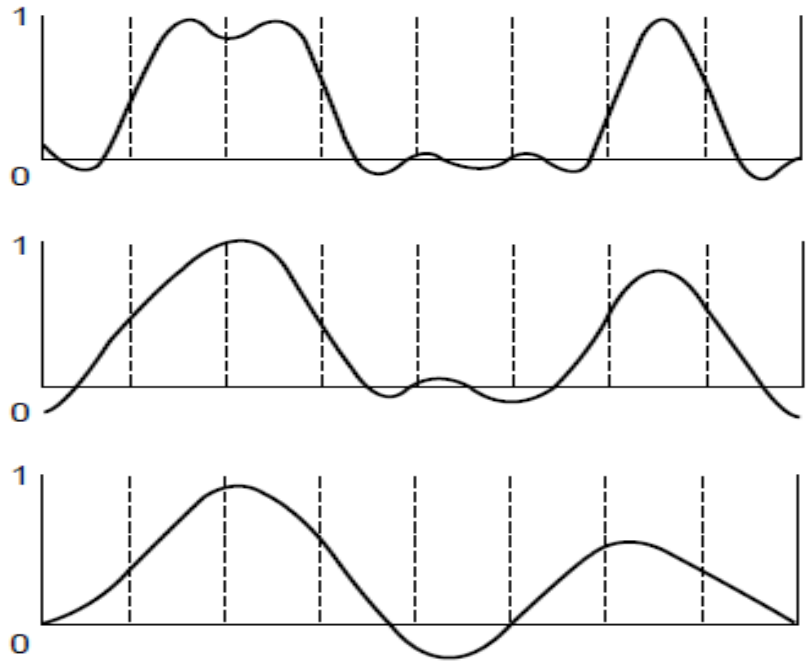
- A signal over time can be represented by its frequency components (called Fourier analysis)

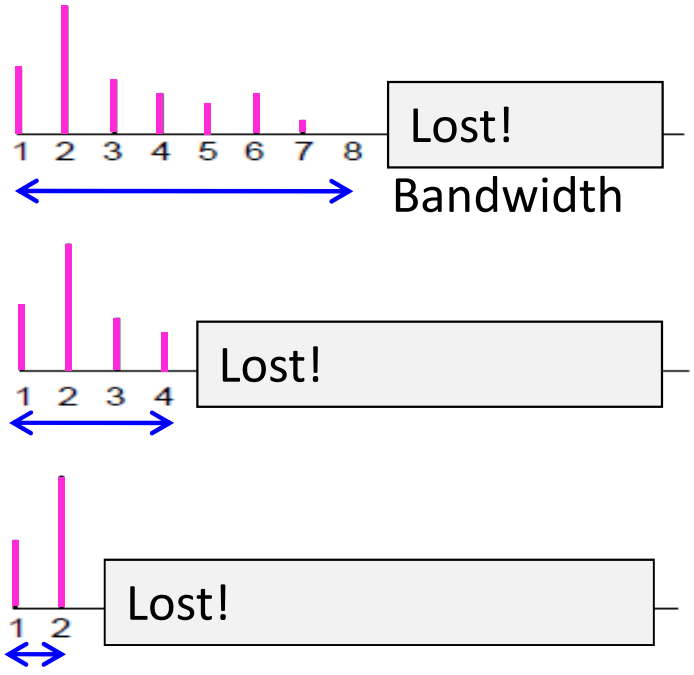
$$g(t) = \frac{1}{2}c + \sum_{n=1}^{\infty} a_n \sin(2\pi nft) + \sum_{n=1}^{\infty} b_n \cos(2\pi nft)$$



Effect of Less Bandwidth

- Fewer frequencies (=less bandwidth) degrades signal





Signals over a Wire

- What happens to a signal as it passes over a wire?
  1. The signal is delayed (propagates at ⅔c)
  2. The signal is attenuated (goes for m to km)
  3. Frequencies above a cutoff are highly attenuated
  4. Noise is added to the signal (later, causes errors)

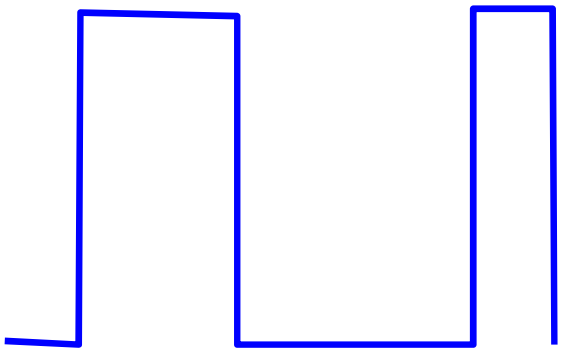
EE: Bandwidth = width of frequency band, measured in Hz
CS: Bandwidth = information carrying capacity, in bits/sec

Signals over a Wire (2)

- Example:

2: Attenuation:

Sent signal

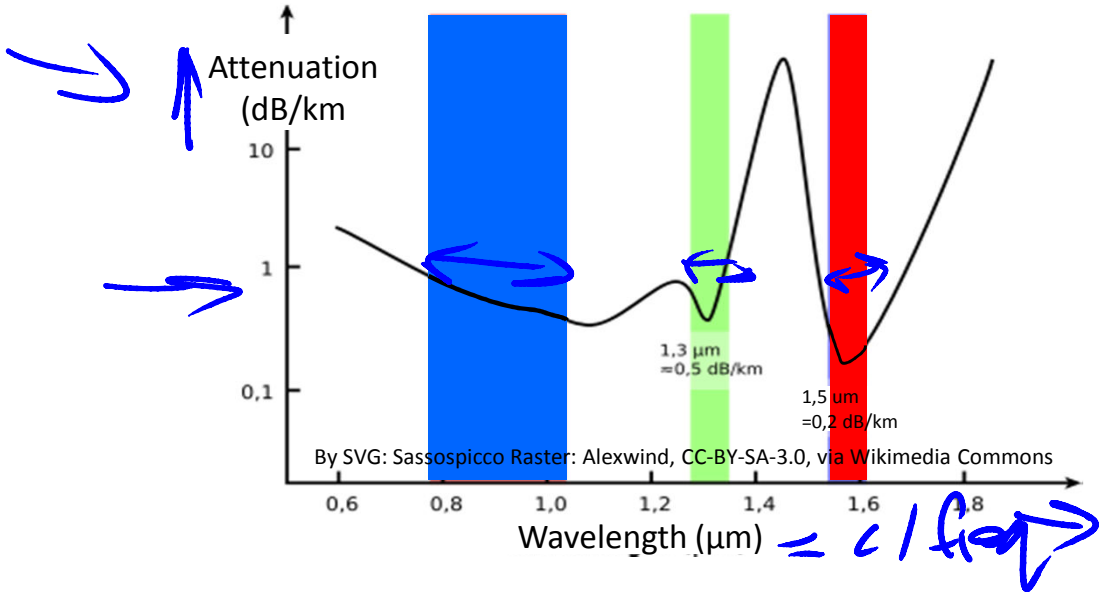


3: Bandwidth:

4: Noise:

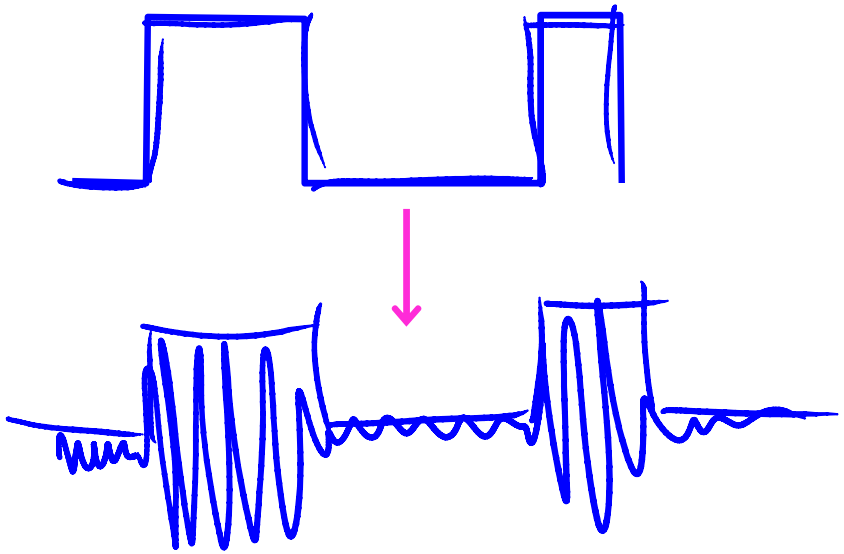
Signals over Fiber

- Light propagates with very low loss in three very wide frequency bands
  - Use a carrier to send information



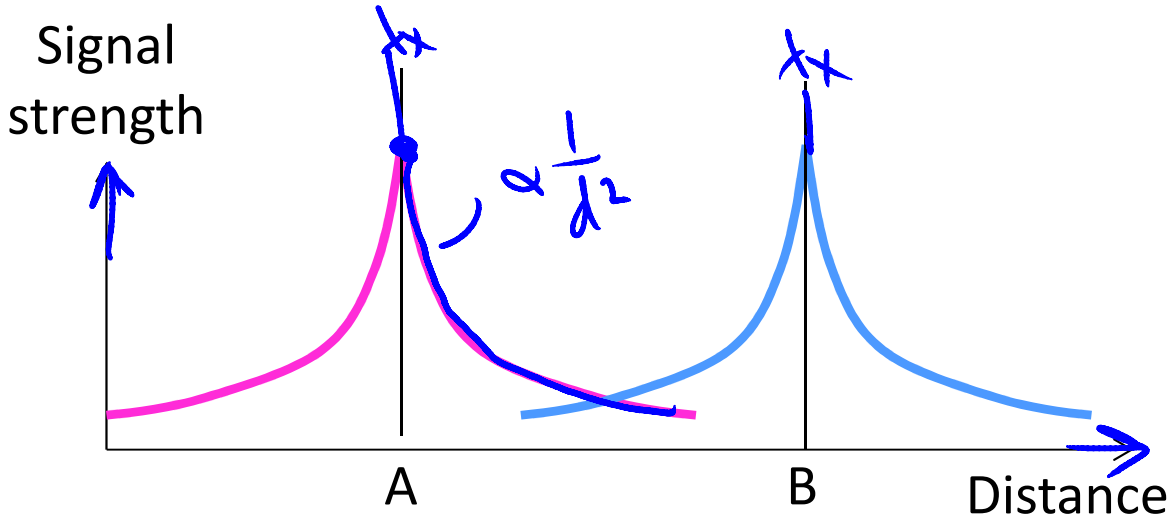
Signals over Wireless

- Signals transmitted on a carrier frequency, like fiber (more later)



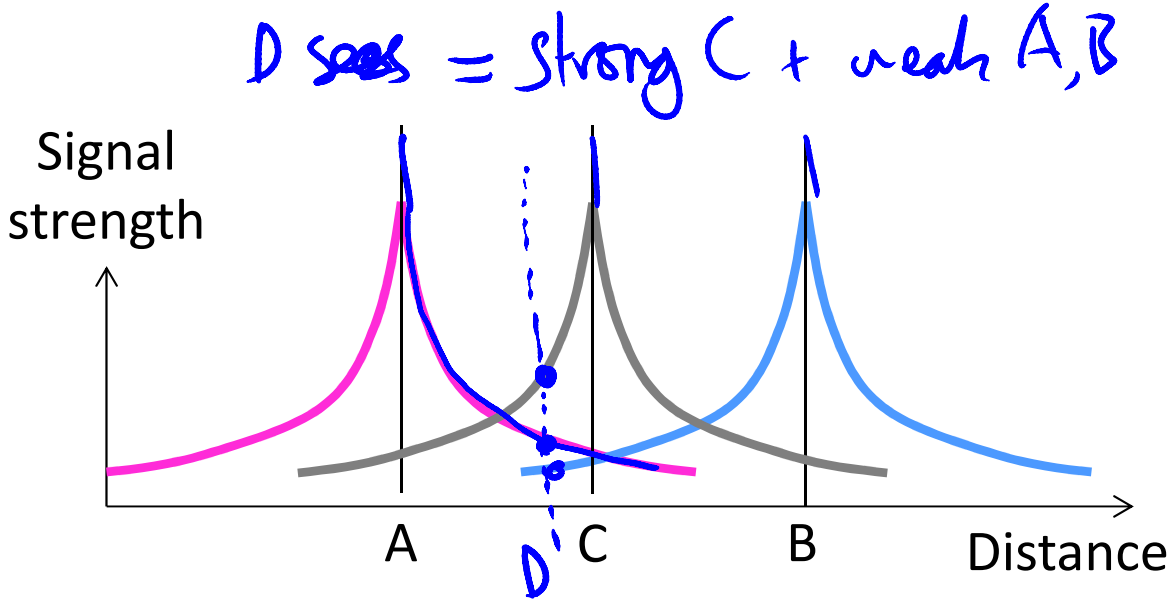
Signals over Wireless (2)

- Travel at speed of light, spread out and attenuate faster than 1/dist^2



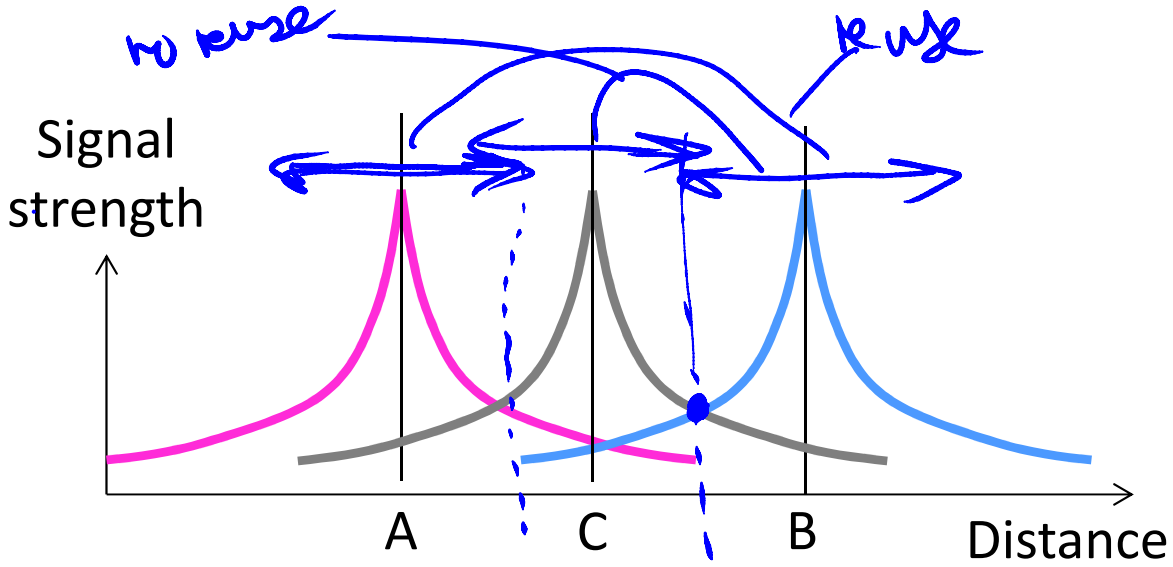
Signals over Wireless (3)

- Multiple signals on the same frequency interfere at a receiver



Signals over Wireless (4)

- Interference leads to notion of <u>spatial reuse</u> (of same freq.)

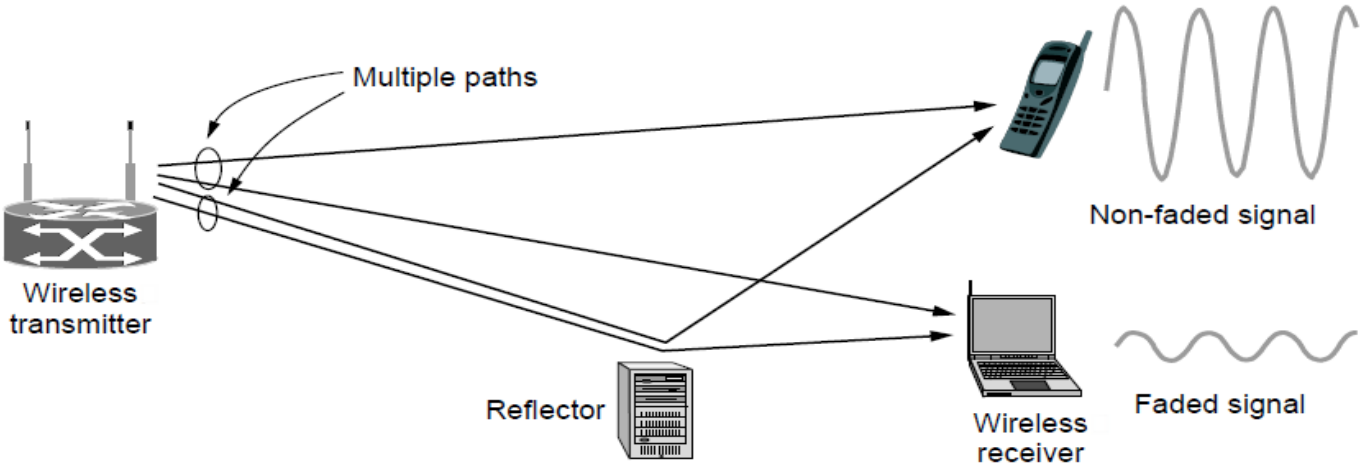


Signals over Wireless (5)

- Various other effects too!
  - Wireless propagation is complex, depends on environment
- Some key effects are highly frequency dependent,
  - E.g., multipath at microwave frequencies

Wireless Multipath

- Signals bounce off objects and take multiple paths
  - Some frequencies attenuated at receiver, varies with location
  - Messes up signal; handled with sophisticated methods (§2.5.3)



END