CS 3251- Computer Networks 1:

Physical Layer

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10/31/13

Lecture 20

Reminders

- Project 3 is due on Tuesday at 5pm.
  - Turn in via T-Square
  - The assignment is already open. Fire away!
- Homework 3 will be released on Tuesday.
  - Last homework of the semester!
- Project 4 will be announced on Thursday!
  - Last project of the semester!

New TLDs!

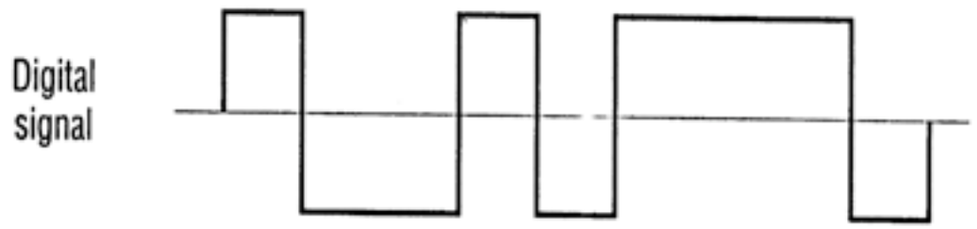
- ICANN has added four new TLDs in the last week.
  - онлайн (“online” in Russian), сайт ("site" in Russian), 游戏 (“game” in Chinese), شبكة ("web" in Arabic)
  - None of these TLDs use latin characters!
- Expect other TLDs including .bank, .disney, etc
  - How many TLDs do we need?
- What about controversial TLDs like .xxx?

The Physical Layer

- The Physical Layer performs bit by bit transmission of the frames given to it by the Data Link Layer.
- The specifications of the Physical Layer include:
  - Mechanical and electrical interfaces
  - Sockets and wires used to connect the host to the network
  - Voltage levels uses (e.g. -5V and +5V)
  - Encoding techniques (e.g. Manchester encoding)
  - Modulation techniques used (e.g. square wave)
  - The bit rate and the baud rate.

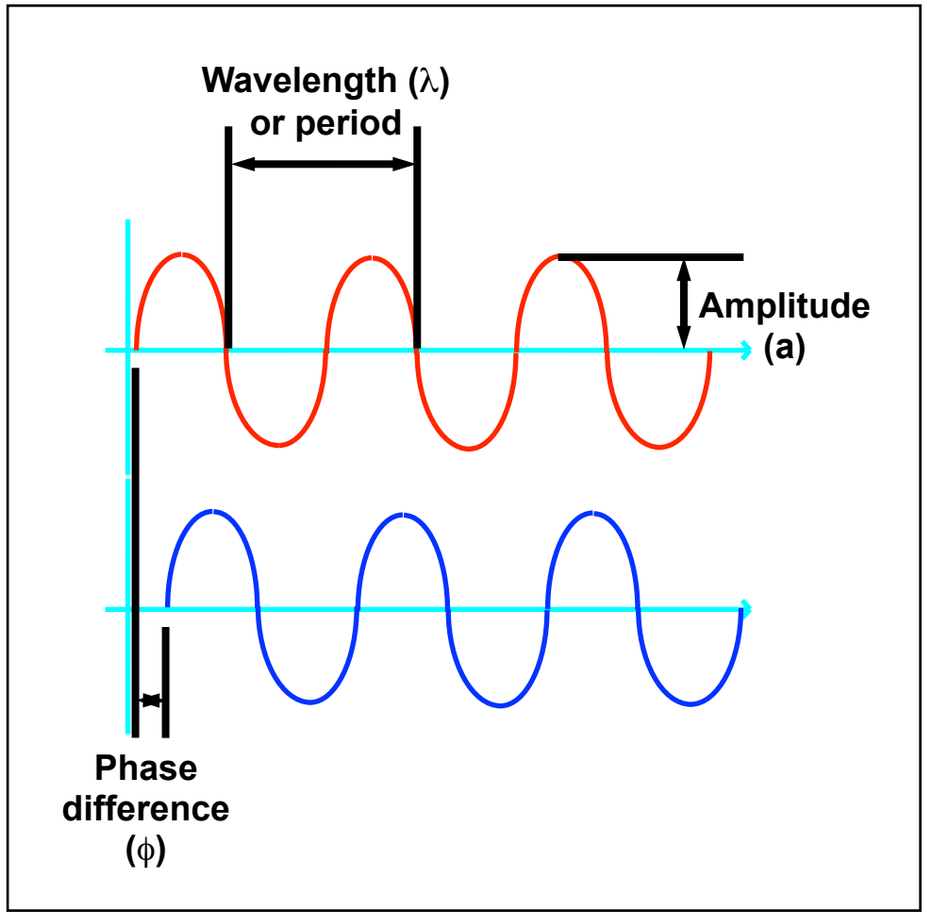
Signal Transmission

- Electronic energy to send signals that communicate from one node to another
- Two methods of transmitting data
  - Digital signaling
  - Analog signaling



Parts of a Wave

- The maximum intensity of a wave is called the amplitude.
- The distance between two crests is the wavelength.
- The number of complete wave cycles every second is the frequency.
- The phase difference measures (as an angle) how far ahead one wave is when compared to another wave.

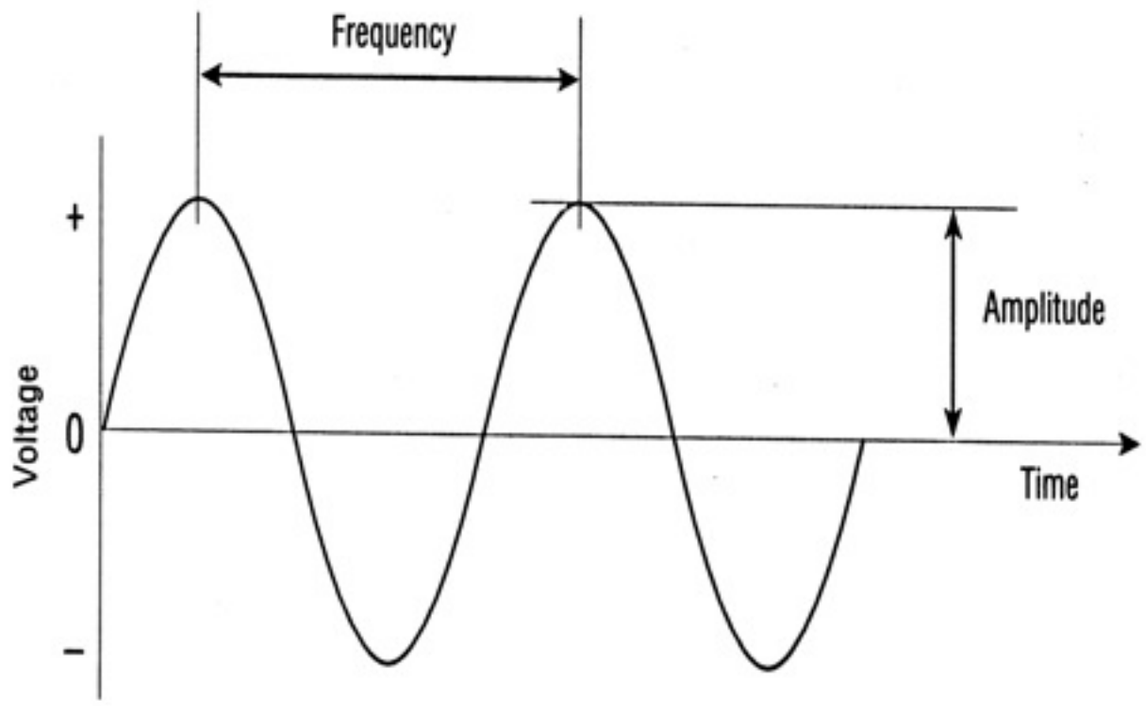


Phase:

Relative state of one wave to another in regards to timing

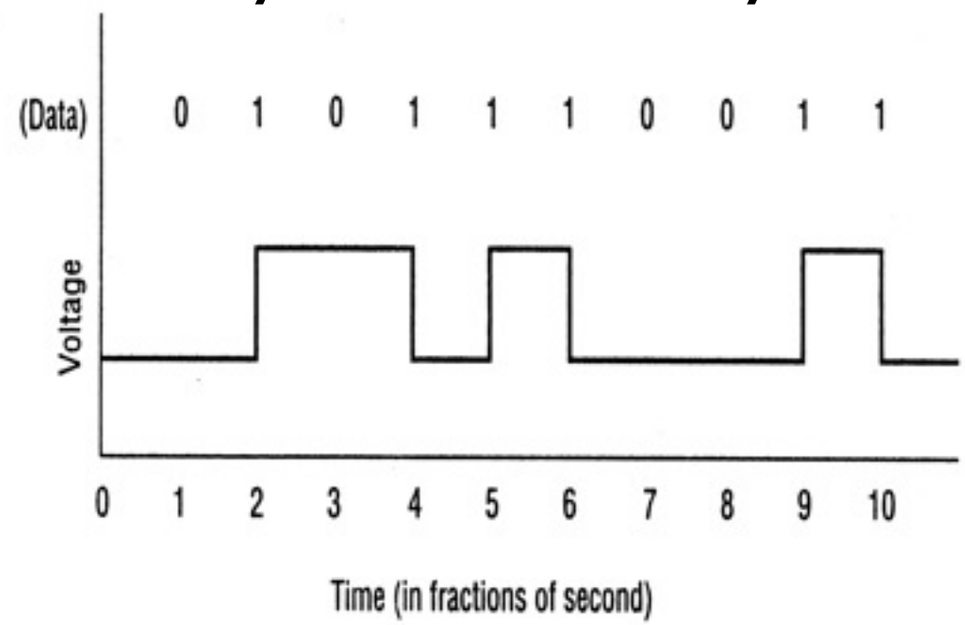
Analog Signaling

- Signals represented by an electromagnetic wave
- Signal is continuous and represents values in a range
- Uses one or more of the characteristics of an analog wave to represent values.

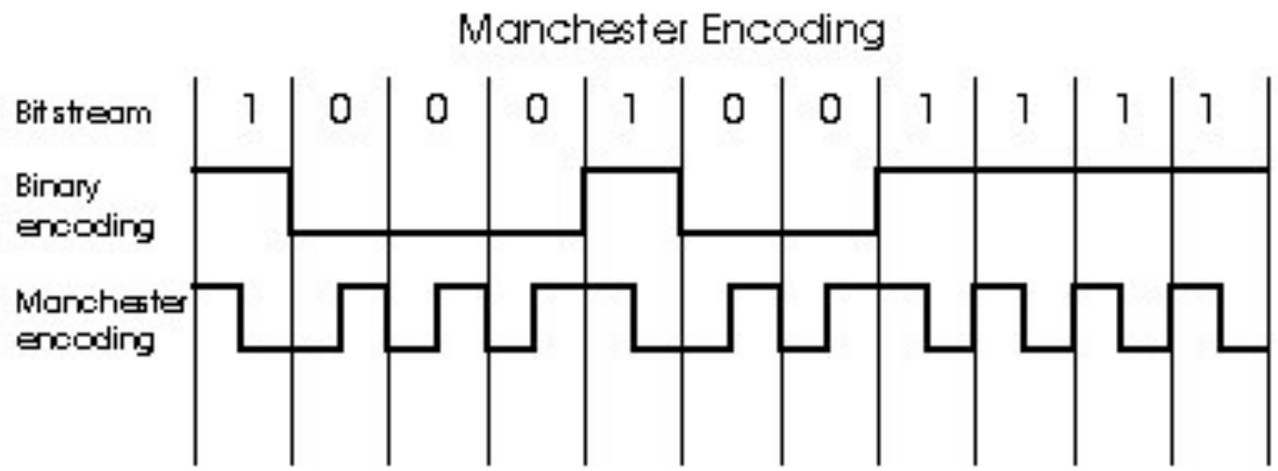


Digital Signaling

- Digital Signaling
  - Digital signal represents discrete state (on or off)
  - Practically instantaneous change
- Current State Encoding
  - Data is encoding by the presence or absence of a signal
  - A positive voltage might represent a binary zero or binary one or visa versa
  - The current state indicates the value of the data



Manchester Encoding

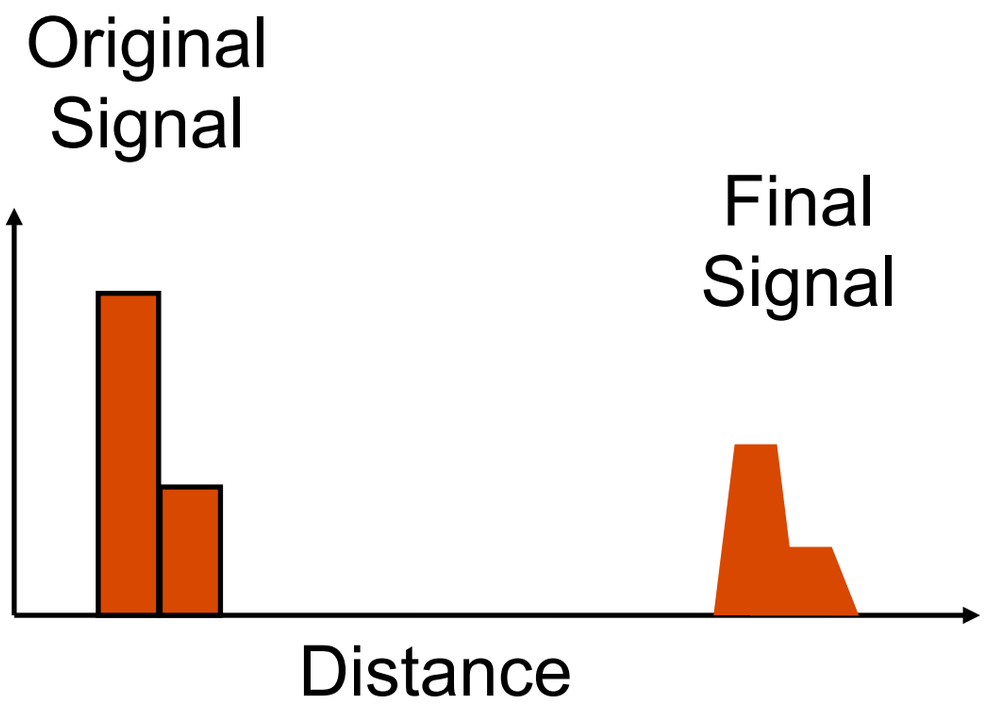


- Each bit is encoded as a transition.

- Why is this better than binary encoding?

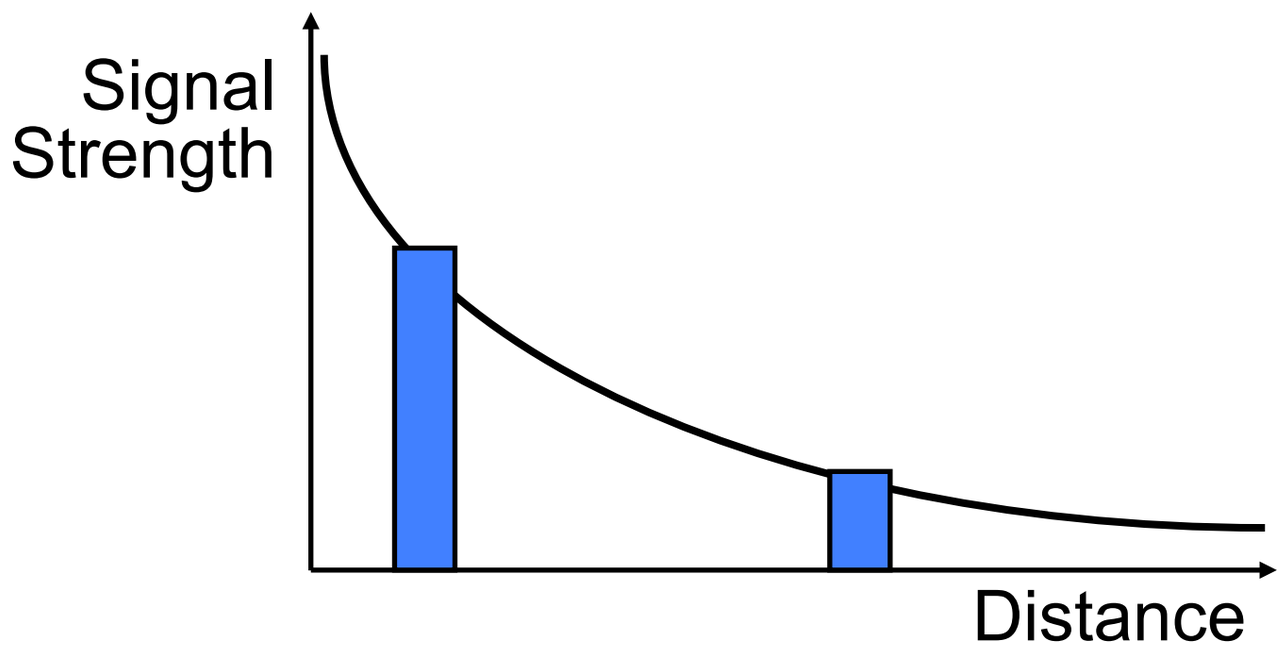
Propagation Effects

- Propagation Effects
  - Signal changes as it travels
  - Receiver may not be able to recognize it



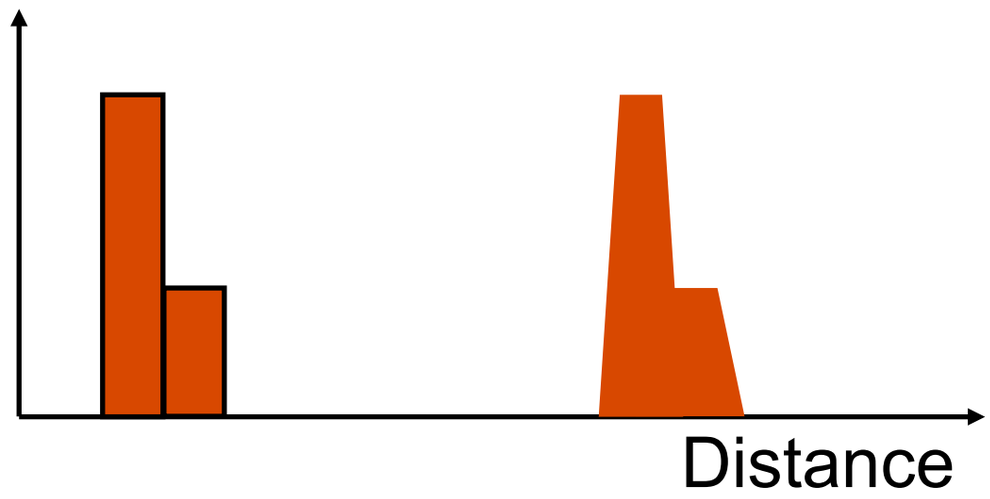
Propagation Effects: Attenuation

- Attenuation: signal gets weaker as it propagates
  - Attenuation becomes greater with distance
  - May become too weak to recognize
  - In wireless networks, this is generally a function of the square of the distance.



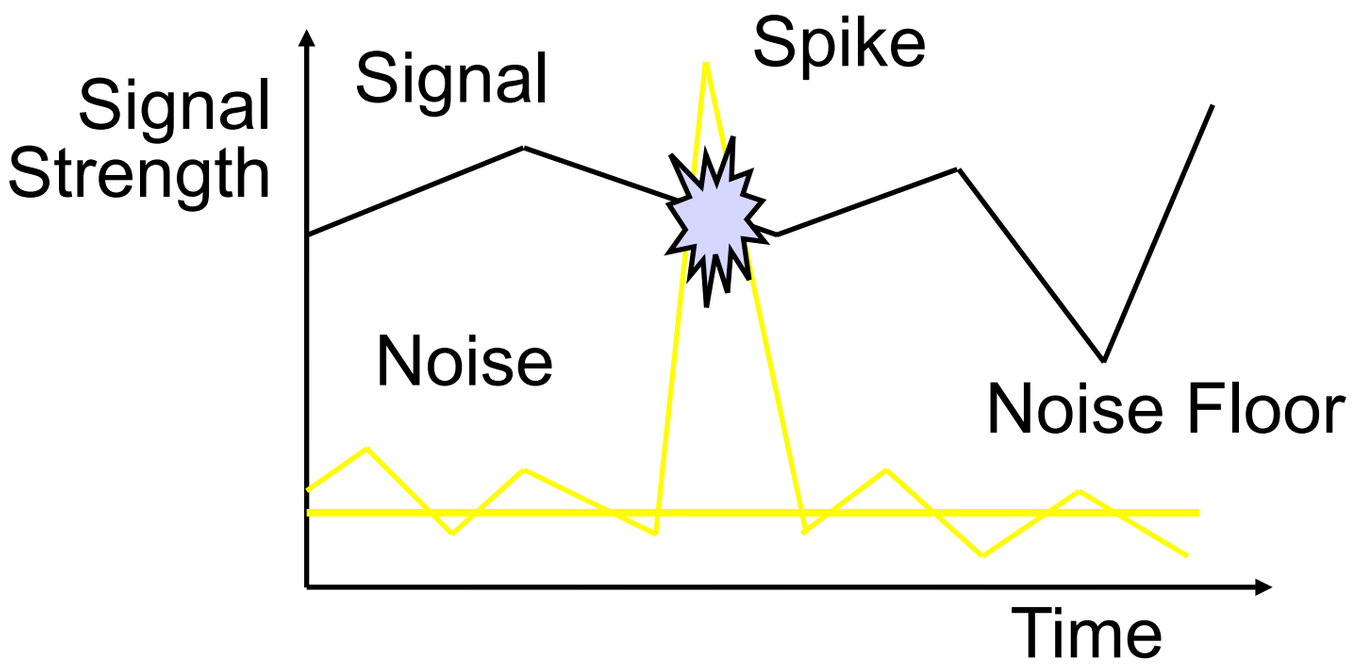
Propagation Effects: Distortion

- Distortion: signal changes shape as it propagates
  - Adjacent bits may overlap
  - May make recognition impossible for receiver



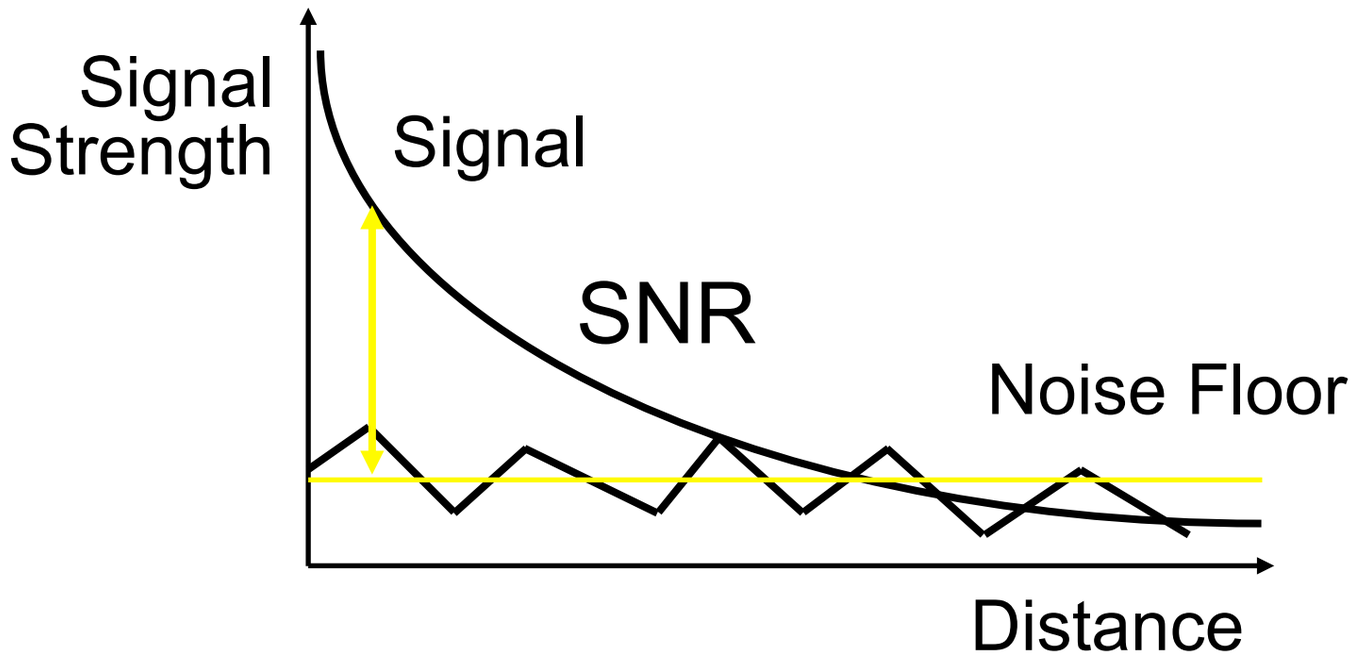
Propagation Effects: Noise

- Noise: thermal energy in wire adds to signal
  - Noise floor is average noise energy
  - Random signal, so spikes sometimes occur



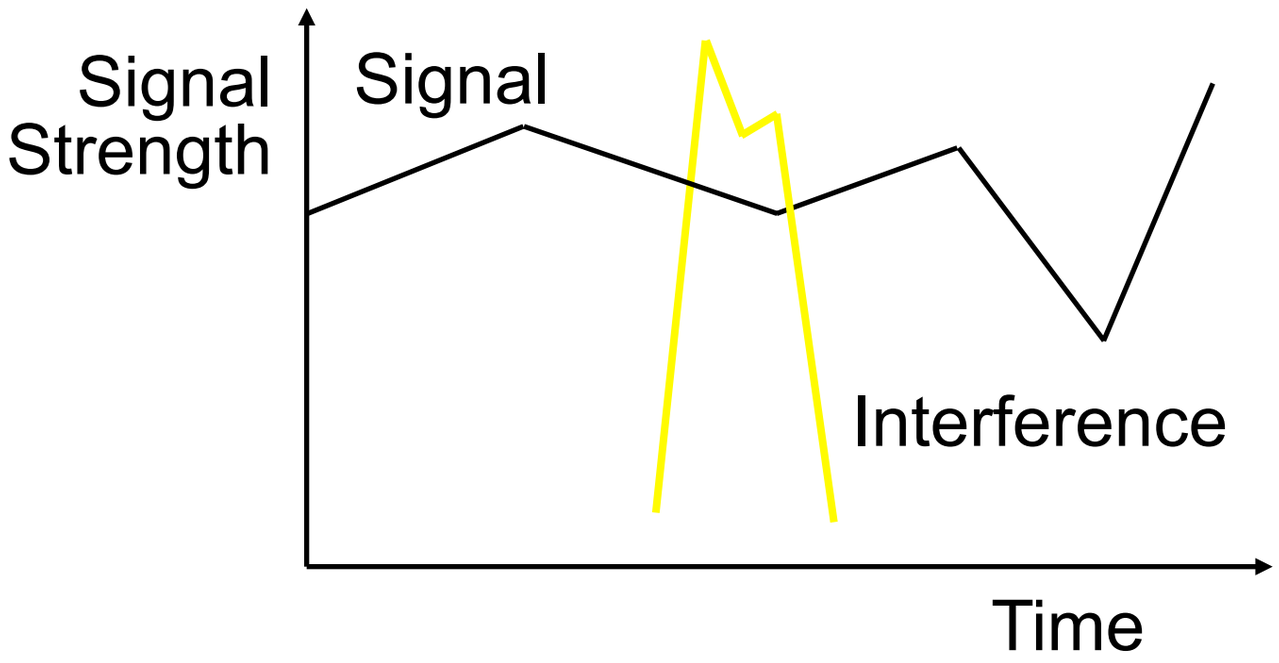
Propagation Effects: SNR

- Want a high Signal-to-Noise Ratio (SNR)
  - Signal strength divided by average noise strength
  - As SNR falls, errors increase



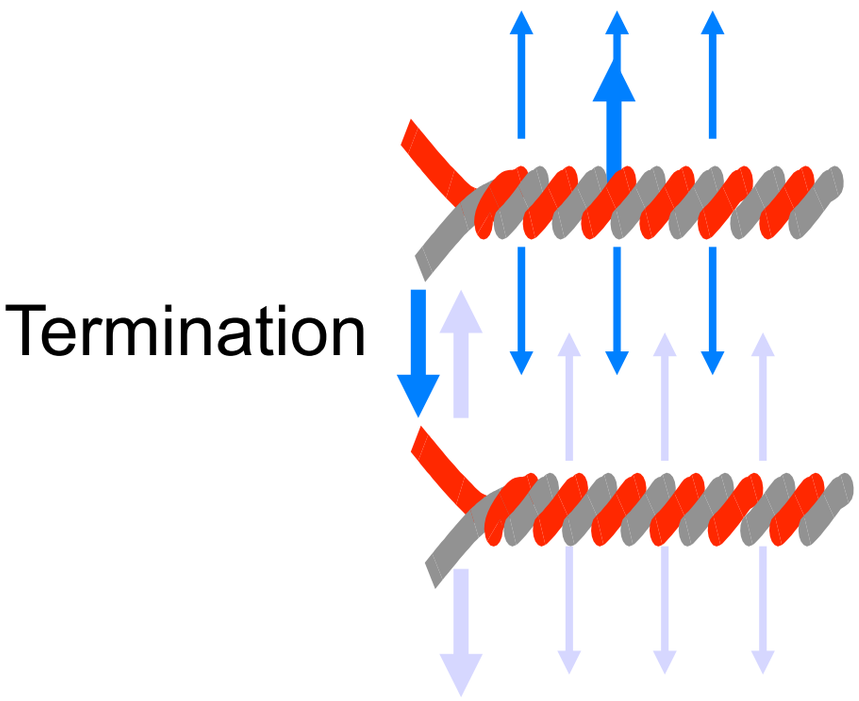
Propagation Effects: Interference

- Interference: energy from outside the wire
  - Adds to signal, like noise
  - Often intermittent, so hard to diagnose



Propagation Effects: Termination

- Interference can occur at cable terminator (connector, plug)
  - Often, multiple wires in a bundle
  - Each radiates some of its signal
  - Causes interference in nearby wires
  - Especially bad at termination, where wires are unwound and parallel



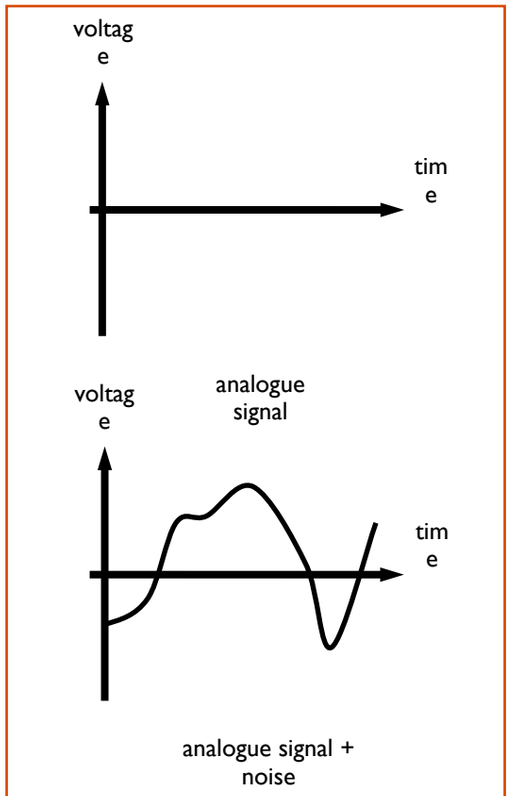
Bandwidth

- Capacity of a media to carry information
- Total capacity may be divided into channels
- A channel is a portion of the total bandwidth used for a specific purpose
- Baseband
  - The total capacity of the media is used for one channel
  - Most LANs use baseband
- Broadband
  - Divides the total bandwidth into many channels
  - Each channel can carry a different signal
  - Broadband carries many simultaneous transmissions

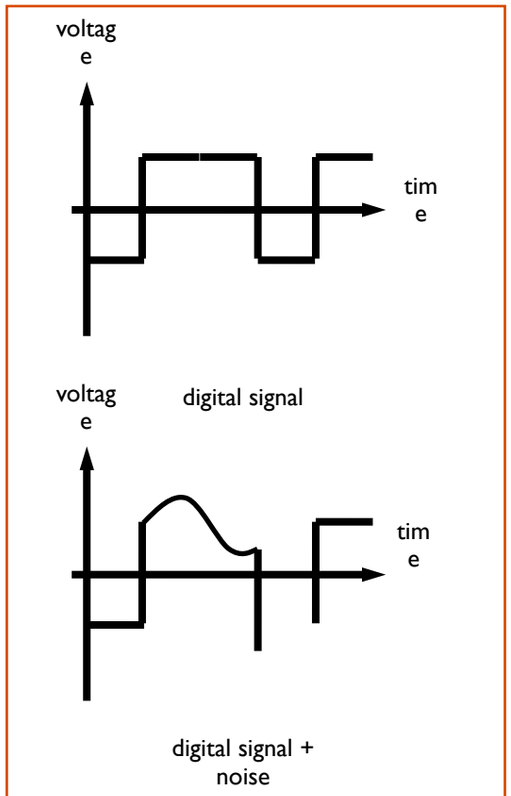
Analog vs Digital

- Digital
  - Is less error prone
  - Distortion of the signal between the source and destination is eliminated
- Analog
  - Little control over the signal distortion
  - Old technology

In digital communication, it is often possible to reconstruct the original signal even after it has been effected by noise



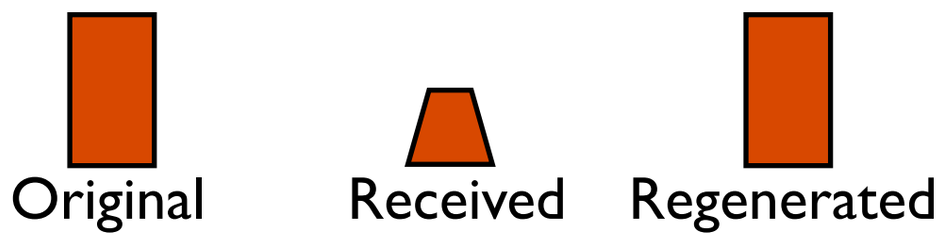
When noise effects an analogue signal, it is hard to deduce the original signal.



The original digital signal can be deduced despite the noise.

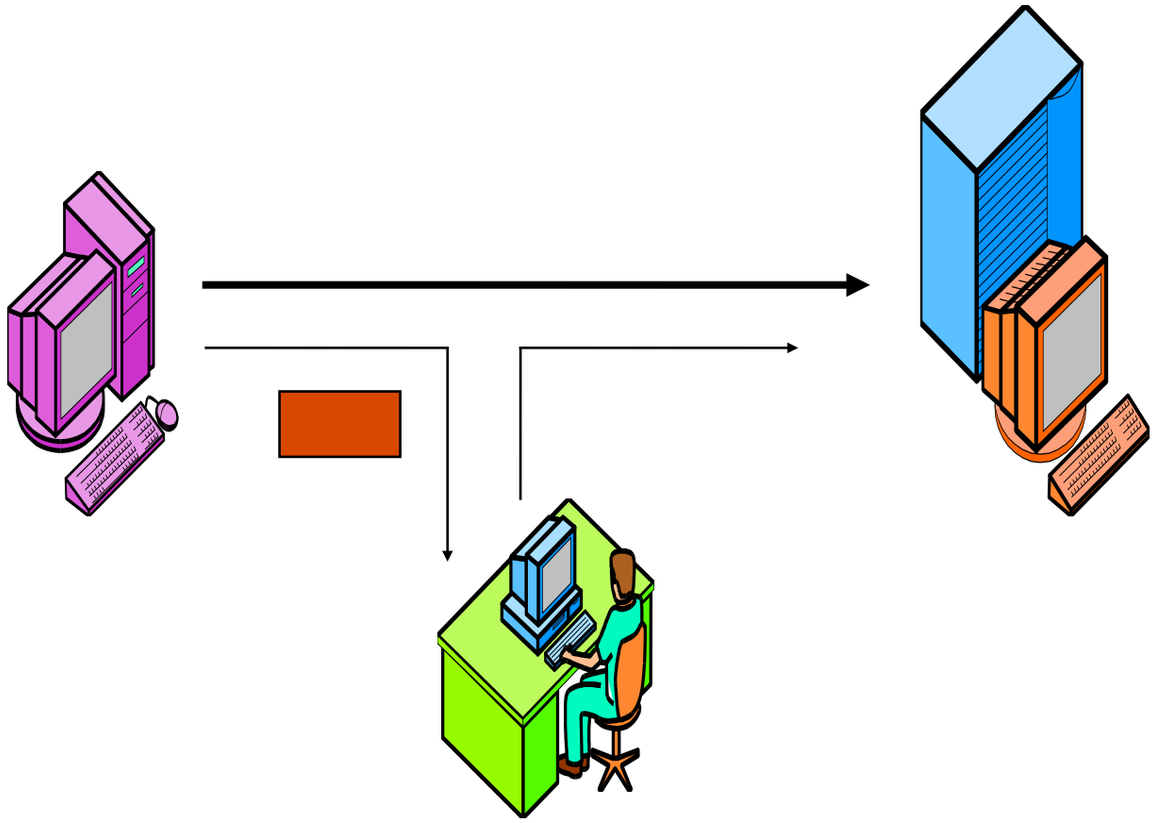
Benefits of Digital Transmission

- Reliability
  - Can regenerate slightly damaged signals
  - There are only two states. Change to closest
  - E.g., if two states are voltages +10v (1) and -10v (0) and the signal is +8v, the signal is a 1
- Error detection and correction
  - Can correct errors in transmission
  - Add a few bytes of error checking information
  - Can ask for retransmission if an error is detected

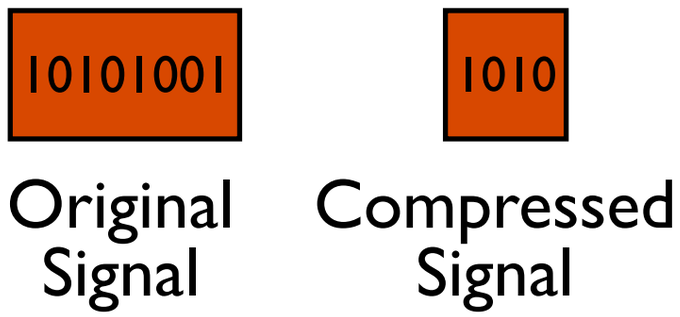


Benefits of Digital Transmission

- Encryption
  - Encrypt (scramble) messages so that someone intercepting them cannot read them

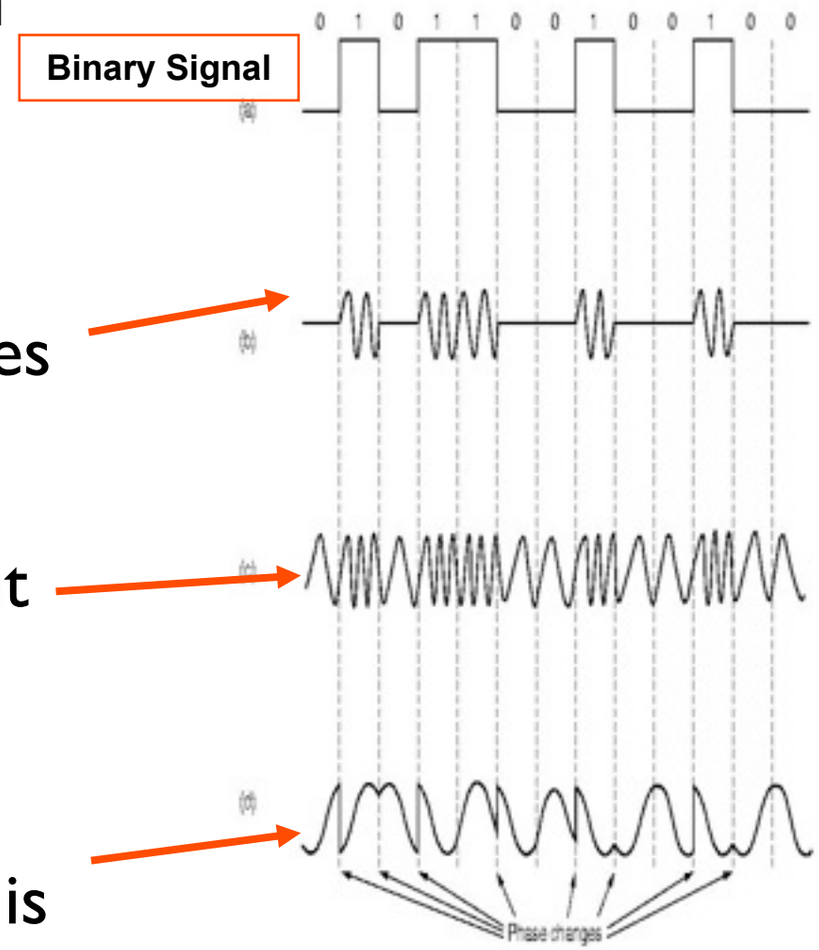


- Compression
  - Compress message before transmission
  - Decompress at other end
  - Compressed message places lighter load on transmission line, so less expensive to send
  - Not always used



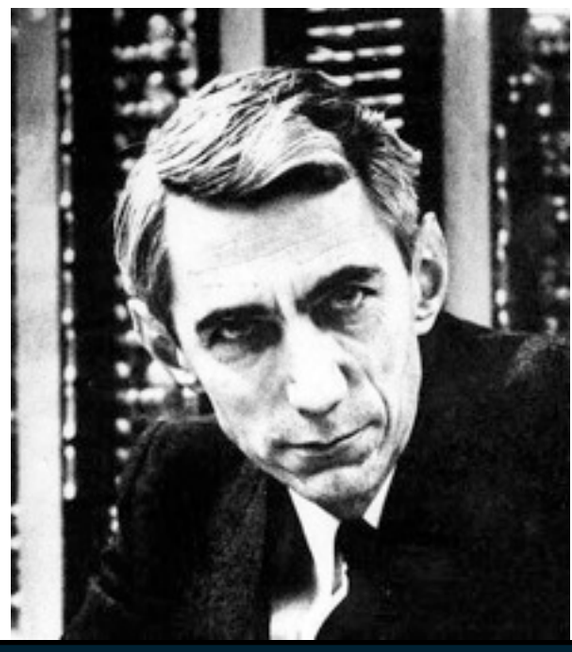
Modulation

- Because attenuation is frequency dependent, modems use a sine wave carrier of a particular frequency, and then modulate that frequency. Various modulations include:
  - Amplitude modulation: Two different amplitudes of sine wave are used to represent 1's and 0's.
  - Frequency modulation: Two (or more) different frequencies, close to the carrier frequency, are used.
  - Phase modulation: The phase of the sine wave is changed by some fixed amount.



Shannon's Theorem

- Claude Shannon extended Nyquist's work to consider the maximum data rate of a noisy channel.
- If a noisy channel has bandwidth *B* Hz, and the signal to noise ratio is *S/N*, then the maximum number of bits/sec *C* is:
  - $C = B \log_2(1+S/N)$
  - SNR typically given in decibles (dB)
    - SNR (dB) = 10 $\log_{10}$ (S/N)



Channel Types

- A channel is any conduit for sending information between devices.
- A simplex channel is unidirectional, which means data can only be sent in one direction.
  - For example, a TV channel only carries data from the transmitter to your TV set. Your TV set cannot send information back.
- A half-duplex channel allows information to flow in either direction (but not simultaneously).
  - Devices at either end of the channel must take it in turns to transmit information whilst the other listens.
  - For example, a walkie-talkie either transmits or receives but not both at the same time.
- A full-duplex channel allows data to be sent in both directions simultaneously.
  - A full-duplex channel can be formed from two simplex channels carrying data in opposite directions. This may make it more expensive than a half-duplex channel.
  - There is no waiting for turns or for the devices swap roles, as is the case with a half-duplex channel. This means full-duplex can be faster and more efficient.

Media Types

- Types of Media
  - Cable (conducted media)
    - Coaxial
    - Twisted pair (UTP)
    - Shielded twisted pair (STP)
    - Fiber optic
  - Radiated
    - Infrared
    - Microwave
    - Radio
    - Satellite

Media Selection Criteria

- Cost
  - For actual media and connecting devices such as NICs hubs etc
- Installation
  - Difficulty to work with media
  - Special tools, training
- Capacity
  - The amount of information that can be transmitted in a giving period of time
  - Measured as
    - Bits per second bps (preferred)
    - Baud (discrete signals per second)
    - Bandwidth (range of frequencies)
- Node Capacity
  - Number of network devices that can be connected to the media
- Attenuation
  - Weakening of the signal over distance
- Electromagnetic Interference (EMI)
  - Distortion of signal caused by outside electromagnetic fields
  - Caused by large motors, proximity to power sources
- Other noise sources
  - White (Gaussian) noise
  - Impulse noise
  - Crosstalk
  - Echo

Physical Layer - Redux

- There are countless issues to be dealt with here.
  - Think of all the new devices that have been created in the past decade. So many use different physical layer technologies.

- Students interested in getting hands-on experience with all of the layers discussed in this class should consider taking CS 4270 in the Spring (Prof. Dovrolis)!

- Students interested in a deeper dive into these protocols and want to learn more about the cutting edge of networking should consider taking CS 4251 in the Spring (Prof Ammar)!