CS 4/5231
Internet Engineering

Kent State University
Dept. of Computer Science

LECT-3

Today's Topic

Communication Point to Point

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Point To Point Communication

Transmission Media
Local Asynchronous Communication
Long Distance Communication
Packets, Frames & Error Detection

Transmission Media-1

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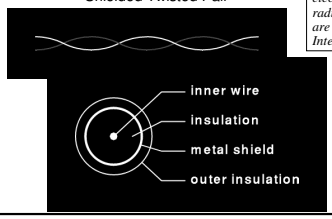
- Copper Wires
  - Twisted Pair
  - Co-axial Cable
  - Shielded Twisted Pair

Wires emmits electromagnetic radiation and Thus are prone to Interference.



Transmission Media-2

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- Glass Fibers
  - advantages
    - No electro-magnetic Interference
    - Long signaling distance
    - Higher capacity
    - One string
  - disadvantages
    - special interface polishing at end points
    - difficult to find breaks
    - difficult to repair breaks

Transmission Media-3

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- Radio
  - Electromagnetic radiation
  - No wiring needed.
  - Antennas can be small (as small as 12") or large.
  - Do not bend (however, can be combined with satellites).
- Microwave
  - Still electromagnetic radiation, but higher frequency.
  - But, it is point-to-point not a broadcast.
  - Others can not intercept.
  - Requires almost line of sight (no metal) path.

Transmission Media-4

- Satellites
  - longer distance, inherently broadcast
  - **GEO**
    - 20,000 miles/36,000km 250 ms delay
    - requires 4-8 degree separation or 45-90 units only
  - LEO
    - 200-400 miles lower delay.
    - Complex control problem.
    - Solution satellite array.
    - demo

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Transmission Media-5

- Infrared
  - small distance, very effective
  - inexpensive.
  - Popular choice for home electronics.
- Laser
  - still light waves, but now through air not fiber.
  - requires line of sight path.
  - Unfortunately cannot penetrate vegetation, fog rain.
  - Very limited in ground.

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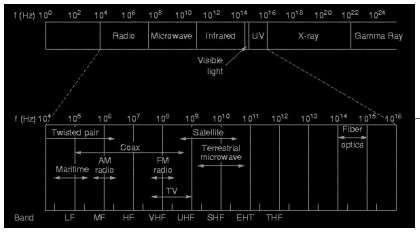
EM Spectrum



Log scale

- High, Very High, Super, Ultra, Extremely, Incredibly, Astonishingly, Prodigiously!

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Bits over Medium

Local Asynchronous Communication

- Computers are binary. So for communication a means is needed to send strings of 1 and 0s.
- A combination of positive and negative voltage can be used to transmit these 1 0 bits across a wire
- Asynchronous Communication
  - Sender does not know if the other is ready to receive.
  - The protocol itself makes the other end aware.
  - Sender can wait arbitrary long between transmissions.

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Standards

- Standards are needed so that every one's equipment can communicate with others.
- Few standardization bodies:
  - International Telecommunication Union (ITU),
  - Electronic Industries Association (EIA)
  - Institute for Electrical & Electronics Engineering (IEEE)

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RS-232

- RS-232 is a popular standard used for **asynchronous** and **serial** communication. It is used for character transmission across short distances between computer and devices (a device such as modem, keyboard, or terminal).

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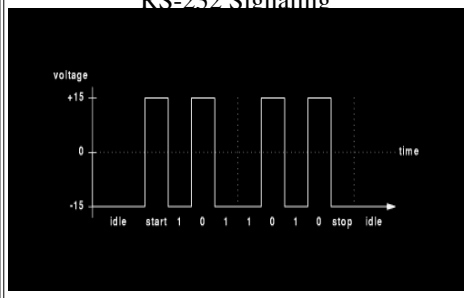
RS-232 Signaling



- Framing Error Handling: BREAK (long 1s)

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Baud Rate

- Both side must know the bit duration. This is done by agreeing on a Baud Rate.
- Bits per second can be 300, 9600, 192000, etc.
- Generally, Manufacturers design a Hardware which can operate at multiple baud rates.
- It can be set both in HW or manually, with SW.
- Without proper setting there will be error.

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Full Duplex Communication

- Simultaneous communication in two directions between two computers is known as Full Duplex communication.
- One way communication requires 2 wires. One for signal, other for ground. Full duplex can be performed by 3 wires.

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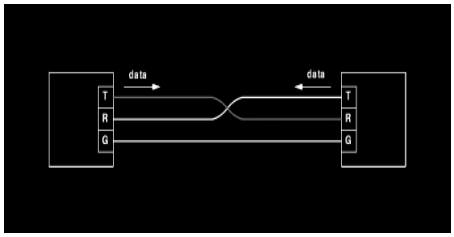
RS-232 Full Duplex Communication

- RS-232 full duplex defines a 25 wire scheme to connect two ends.



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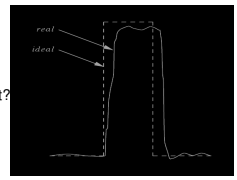
Limitation of Medium

Limitation of Real Hardware



- How fast can we transmit?
- RS-232 recommends taking samples at the middle of the time slot.
- RS-232 recommends taking samples at the middle of the time slots, not at the beginning, or end.

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Theoretical Limit

- Each transmission media has a physical limit, how fast it can change its signal levels. This is knows as Bandwidth.
- In 1920s, Nyquest provided the maximum limit. If a transmission system uses K values of voltages (instead of 2), Nyquest Theorem states that the maximum data rate in bps is:

$$D=2\ B\ \log_2 K$$

- This is an absolute maximum. Real systems can carry much less because of noise.
- In 1948, Shannon connected it with Noise level, which now allows engineer to find out real limits.

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Nyquist Theorem

- For a H Hz channel (a low pass channel with cutoff at H hz), if a signal consists of V discrete levels, then the maximum data rate is:

$$D = 2H \log_2 V \text{ bits/sec}$$

Example: a noiseless 3-kHz channel cannot transmit binary (two level) signals at a rate exceeding 6000 bps

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Shannon's Theorem

- Maximum data rate for a noisy channel whose bandwidth is H Hz, and whose signal to noise ratio is S/N, is given by:

$$M = H \log_2 (1+S/N) \text{ bits/s}$$

S/N is expressed as decibels (DB). A ratio S/N=10 is 10 db, a ratio of 100 is 20 db, a ratio of 1000 is 30 db

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Example Problem

Problem: a 3-kHz channel has 30db signal to noise ratio. What will be the maximum data rate via this channel according to Shannon's result?

Answer:

- H=3000
- 30 db means S/N = 1,000
- M = 3000 x log 1001 = 30,000 bps

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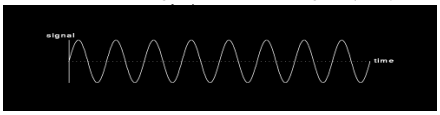
Travelling Long Distance

Long Distance Communication

- RS-232 can not transmit signal via a very long wire
- Signal is lost because of electrical resistance. However, a signal with continuous high frequency



- Signal is encoded by varying the amplitude or the phase of a carries wave.

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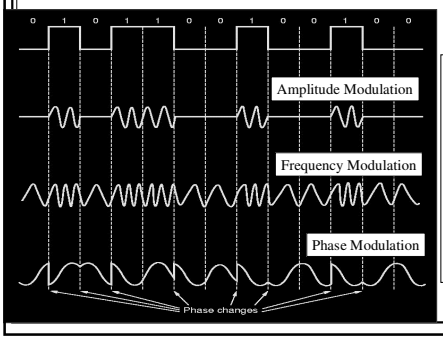
Modulation



- Square waves have a wide spectrum, and thus are subject to strong attenuation, delay distortion and noise.
- Thus DC signals are unsuitable.
- To get around this problem some form of AC is used.

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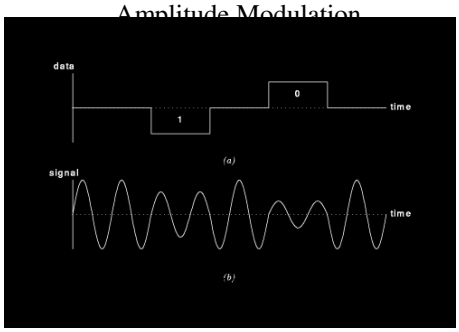
Amplitude Modulation



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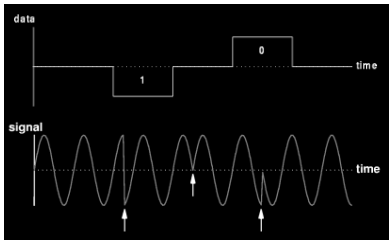
Phase Shift Modulation



- In this example signal is phase shifted 180 degree to indicate 1, and reverted to 0 degree for 0.

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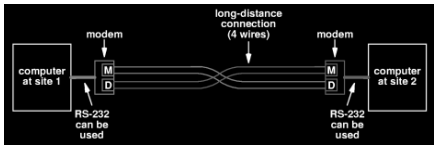
Modem

- A hardware that performs amplitude or phase modulation and demodulation at the two ends of a transmission line is called MODEM.



- All long distance communication is performed by modems. The above modem uses 4 wires.

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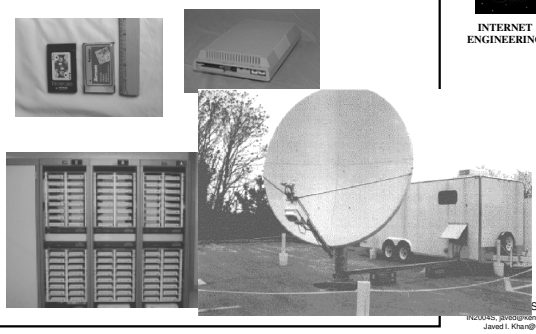
Some Modems



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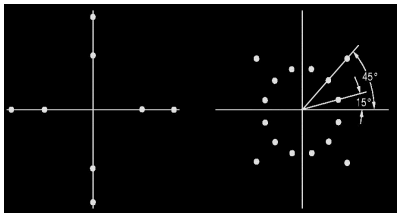
Advanced Modems use Constellation Code



8 points (3 bits) 16 points (4 bits)

With 4 bit per baud 9600 bps can be sent over 2400-baud line

V.32 uses 6 bits per sample at 2400 baud. Its constellation pattern has 64 points.

After v.32 comes V.34 which runs at 28,800 bps.

How We Get the 4 Long Distance Wires?

- Generally Telephone companies have extra wires connected to nowhere!. We can lease them.
- However, modems can be between any kind of transmission media .

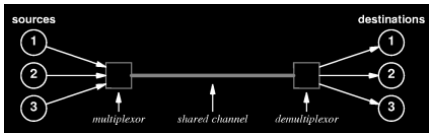
Telephone Modems

- Almost same but has three differences:
  - Has telephone mimic hardware (lift,hang, etc).
  - Carries audible tones.
  - Use two wires for full duplex operation.

Cost?

Can we Share the Point-to-Point Line?

Multiplexing



- Frequency Division Multiplexing
  - Each carrier operates at different frequencies.
  - There is some separation.
- Time Division Multiplexing
  - Each channel takes turns.
  - Most computer networks use it.

Multiplexing Terminologies

- Broadband Technology
  - A technology allows shifting between wide range of frequencies in the electromagnetic spectrum.
- Baseband Technology
  - uses only a small part of the EM band.
- Wave Division Multiplexing
  - FDM in near light frequencies are called WDM
- Spread Spectrum Technology
  - spreads a single signal over multiple frequencies dynamically based on error characteristics of the medium.

Packets, Frames & Error Detection

- Most computers do not send an arbitrary amount of data continuously. These are generally divided into small blocks called packets.
- Why Packet?
  - Error is also packetized.
  - Network and all underlying media can be shared

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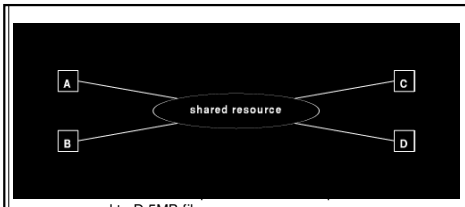

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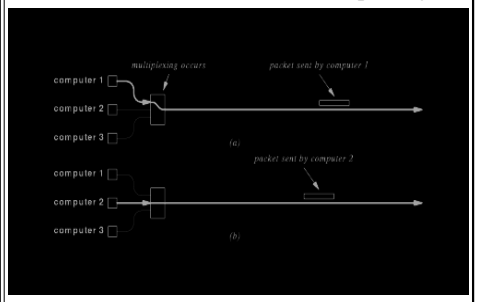
send to D 5MB file.
- What happens to transmission time? (12 min)
- What happens to delay for B and C?

- What if now A sends packets of 1000 bytes?
  - What happens to delay? (about .143 seconds!)
  - What happens to transmission time? (same)

Packets & Time-Division Multiplexing



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Packets and Hardware Frames

- Each hardware technology defines a detail of Packets which is knows as frame.
- To send a block of data, each technology should define how to specify begin and end of a packet.

Overhead? What if we use only SOH?

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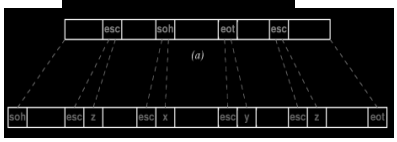
Byte Stuffing

- Wha hing?

Character In Data	Characters sent
soh	esc x
eot	esc y
esc	esc z



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Transmission Error

Guarding against Faults

- Lighting, power surges, and other electromagnetic interference can cause unwanted electrical currents in wires.
- Much of the complexity of computer network arises because digital transmission systems are susceptible to interference that can cause random data to appear or transmitted data to be lost or changed.
- As we prepare for longer and larger communication, we accumulate more chances or error.

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Transmission Errors

- Parity Bits:
  - Used by RS-232
  - Sender generally send an additional bit called parity bit.
  - Odd and Even parity
  - Receiver removes them.
  - Limitations
    - Can detect 1 bit error.
    - Cannot detect 2 bit errors, or errors in even number of bits.
- There are many ways of error correction and detection .
  - Computation complexity
  - number of bit-error they can correct.
  - Number of extra-bit they need.

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Checksum

- Advantages:
  - Easy in Hardware with fixed (16 or 32 bit) blocks.
  - Most use one checksum for entire packet.

H	e	l	l	o		w	o	r	l	d	.
48	65	6C	6C	6F	20	77	6F	72	6C	64	2E

4865 + 6C6C + 6F20 + 776F + 726C + 642E + carry = 71FC

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Checksum (more)

- Disadvantages: Cannot correct many common errors.

Data Item In Binary	Checksum Value	Data Item In Binary	Checksum Value
00001	1	00011	3
00010	2	00000	0
00011	3	00001	1
00001	1	00011	3
totals	7		7

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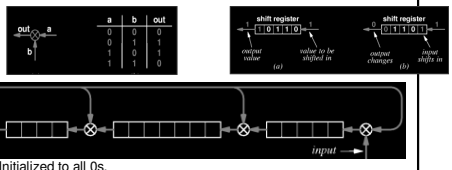
Error Detection with CRC

- A theoretically complex, but easy to implement and powerful error detection method.
- Uses XOR and SHIFT-REGISTERS



- Initialized to all 0s.
- The bits of the entire message is shifted in.
- At the end the registers contains 16-bit CRC.
- Receiver uses identical hardware to compute CRC
- Excellent for Burst errors!

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Frame Format with Error Detection

soh	block of data with byte stuffing	eot	CRC

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