

Today's Topic

Communication Point to Point



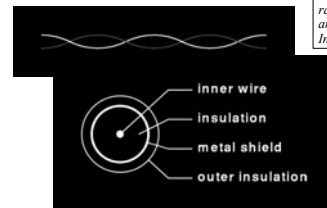
Point To Point Communication

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

Transmission Media-1

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

*Wires emits
electromagnetic
radiation and Thus
are prone to
Interference.*



Transmission Media-2

- 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

- 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

- 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.



INTERNET
ENGINEERING

LECT-3, S-7
IN2007F_javed@kent.edu
Javed I. Khan@2004

Transmission Media-5

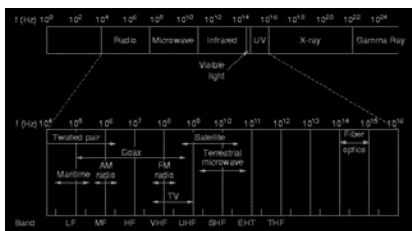
- Satellites
 - longer distance, inherently broadcast
 - GEO
 - 20,000 miles/36,000km 250 ms delay
 - requires 4-8 degree separation or 45-90 units only
 - LEO
 - 200-400 miles lower delay.
 - Complex control problem.
 - Solution satellite array.
 - demo
 - Gliding Aircraft or Balloon
 - Micro Satellite (design table)



INTERNET
ENGINEERING

LECT-3, S-8
IN2007F_javed@kent.edu
Javed I. Khan@2004

EM Spectrum



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



INTERNET
ENGINEERING

LECT-3, S-9
IN2007F_javed@kent.edu
Javed I. Khan@2004

Bits over Medium

10

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.



INTERNET
ENGINEERING

LECT-3, S-11
IN2007F_javed@kent.edu
Javed I. Khan@2004

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)



INTERNET
ENGINEERING

LECT-3, S-12
IN2007F_javed@kent.edu
Javed I. Khan@2004

RS-232

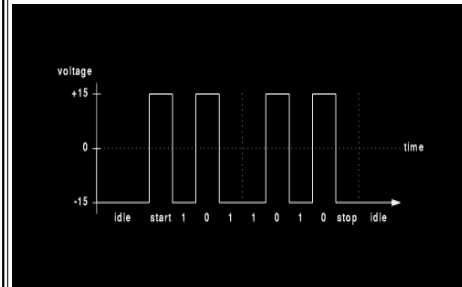
- RS-232 is a popular standard used for **asynchronous** and **serial** communication. Also known as SERIAL interface.
- It is used for character transmission across short distances between computer and devices (a device such as modem, keyboard, or terminal).



INTERNET
ENGINEERING

LECT-3, S-13
IN2007F_javed@kent.edu
Javed I. Khan@2004

RS-232 Signaling



- Framing Error Handling: BREAK (long 1s)



INTERNET
ENGINEERING

LECT-3, S-14
IN2007F_javed@kent.edu
Javed I. Khan@2004

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.



INTERNET
ENGINEERING

LECT-3, S-15
IN2007F_javed@kent.edu
Javed I. Khan@2004

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.

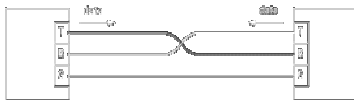


INTERNET
ENGINEERING

LECT-3, S-16
IN2007F_javed@kent.edu
Javed I. Khan@2004

RS-232 Full Duplex Communication

- RS-232 full duplex defines a 25 wire scheme to connect two ends.
- However, many of its pins are control. It can be configured to communicate with 3 wires as following:



- To make wiring simple, most modems transmit and receive in opposite pins.



INTERNET
ENGINEERING

LECT-3, S-17
IN2007F_javed@kent.edu
Javed I. Khan@2004

Universal Serial Bus

- Designed to Replace SERIAL (RS 232) and PARALLEL Ports
 - Designed in 1996.
- Much Higher Data Transfer Rate
 - 1.0 1.5 Mbps, 1.1 12 Mbps and 2.0 480 Mbits/sec
- **Connect Large Number of Devices** (127 per host)
- Many Modern Self Configuring Features
 - Plug & Play Device
 - Automatic Device Identification & Driver Installation
 - Hot Swapping.
- Can also supply power to devices.

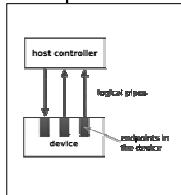


INTERNET
ENGINEERING

LECT-3, S-18
IN2007F_javed@kent.edu
Javed I. Khan@2004

USB (Universal Serial Bus)

- A USB system consists of a host controller and many downstream USB ports, and multiple peripheral devices connected in a tiered-star topology.
- Additional USB hubs may be included in the tiers, allowing branching into a tree structure, subject to a limit of 5 levels of tiers per controller. Up to 127 devices, including the hub devices, may be connected to a single host controller.
- Modern computers often have several host controllers, allowing a very large number of USB devices to be connected.



LECT-3, S-19
IN2007F_javed@kent.edu
Javed I. Khan@2004



INTERNET
ENGINEERING

USB (Universal Serial Bus)

- In USB terminology there are many individual devices that are referred to as functions, because each individual physical device may actually host several functions, such as a webcam with a built-in microphone. Functions are linked in series through hubs.
- The hubs are special-purpose devices that are not considered functions. There always exists one hub known as the root hub, which is attached directly to the host controller.
- USB endpoints actually reside on the connected device: the channels to the host are referred to as pipes



INTERNET
ENGINEERING

LECT-3, S-20
IN2007F_javed@kent.edu
Javed I. Khan@2004

USB (Universal Serial Bus)

- Functions and hubs have associated pipes (logical channels). Pipes are connections from the host controller to a logical entity on the device named an endpoint.
- A function can have up to 32 active pipes, 16 into the host controller and 16 out of the controller. Each endpoint can transfer data in one direction only..
- When a device is first connected, the host reads a mandatory descriptor of the device, and loads the device driver it needs.



INTERNET
ENGINEERING

LECT-3, S-21
IN2007F_javed@kent.edu
Javed I. Khan@2004

USB (Universal Serial Bus)

- When a function or hub is attached to the host controller it is given a unique 7 bit address on the bus by the host controller, which essentially concludes the process called "enumeration".
- The host controller then polls the bus for traffic, usually in a round-robin fashion, so no function can transfer any data on the bus without explicit request from the host controller.
- The USB specification provides a 5 V supply on a single wire from which connected USB devices may draw power. Initially, a device is only allowed to draw 100 mA. It may request more current from the upstream device in units of 100 mA up to a maximum of 500 mA.



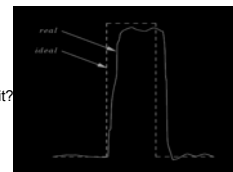
INTERNET
ENGINEERING

LECT-3, S-22
IN2007F_javed@kent.edu
Javed I. Khan@2004

Limitation of Medium

23

Limitation of Real Hardware



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



INTERNET
ENGINEERING

LECT-3, S-24
IN2007F_javed@kent.edu
Javed I. Khan@2004

Theoretical Limit

- Each transmission media has a physical limit, how fast it can change its signal levels. This is known as Bandwidth.
- In 1920s, Nyquist provided the maximum limit. If a transmission system uses K values of voltages (instead of 2), Nyquist 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.



INTERNET
ENGINEERING

LECT-3, S-25
IN2007F, javed@kent.edu
Javed I. Khan@2004

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



INTERNET
ENGINEERING

LECT-3, S-26
IN2007F, javed@kent.edu
Javed I. Khan@2004

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



INTERNET
ENGINEERING

LECT-3, S-27
IN2007F, javed@kent.edu
Javed I. Khan@2004

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



INTERNET
ENGINEERING

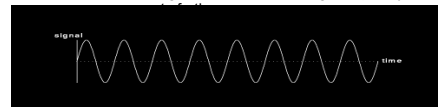
LECT-3, S-28
IN2007F, javed@kent.edu
Javed I. Khan@2004

Travelling Long Distance

29

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 carrier wave.



INTERNET
ENGINEERING

LECT-3, S-30
IN2007F, javed@kent.edu
Javed I. Khan@2004

Modulation

Amplitude Modulation

Frequency Modulation

Phase Modulation

Phase changes

INTERNET ENGINEERING

- 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.

LECT-3, S-31
IN2007F_javed@kent.edu
Javed I. Khan@2004

Amplitude Modulation

(a)

(b)

INTERNET ENGINEERING

LECT-3, S-32
IN2007F_javed@kent.edu
Javed I. Khan@2004

Phase Shift Modulation

(a)

(b)

INTERNET ENGINEERING

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

LECT-3, S-33
IN2007F_javed@kent.edu
Javed I. Khan@2004

Modem

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

INTERNET ENGINEERING

LECT-3, S-34
IN2007F_javed@kent.edu
Javed I. Khan@2004

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

Some Modems

INTERNET ENGINEERING

LECT-3, S-35
IN2007F_javed@kent.edu
Javed I. Khan@2004

LECT-3, S-35
IN2007F_javed@kent.edu
Javed I. Khan@2004

Advanced Modems use Constellation Code

INTERNET ENGINEERING

LECT-3, S-36
IN2007F_javed@kent.edu
Javed I. Khan@2004

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.

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

How We Get the 4 Long Distance Wires?

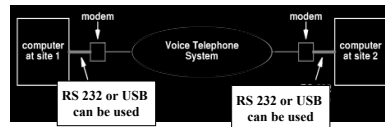
- Generally telephone companies have extra fibers & wires connected to nowhere! We can lease them.
- However, modems can be between any kind of transmission media .



INTERNET
ENGINEERING

LECT-3, S-37
IN2007F, javed@kent.edu
Javed I. Khan@2004

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.



INTERNET
ENGINEERING

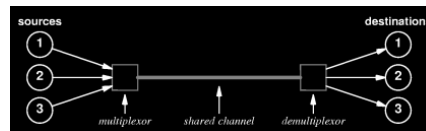
LECT-3, S-38
IN2007F, javed@kent.edu
Javed I. Khan@2004

Cost?

Can we Share the Point-to-Point Line?

39

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.



INTERNET
ENGINEERING

LECT-3, S-40
IN2007F, javed@kent.edu
Javed I. Khan@2004

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.



INTERNET
ENGINEERING

LECT-3, S-41
IN2007F, javed@kent.edu
Javed I. Khan@2004

Packets, Frames & Error Detection

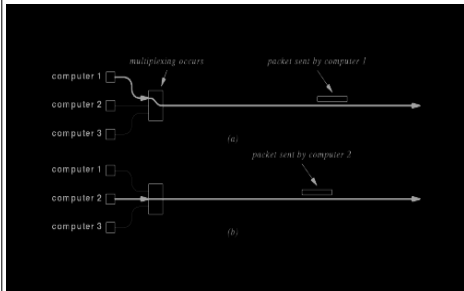
- Most computers do not send an arbitrary amount of data continuously. These are generally divided into small blocks called packets.
- Why Packet?
 - Error is also packetized.
 - Network and all underlying media can be shared



INTERNET
ENGINEERING

LECT-3, S-42
IN2007F, javed@kent.edu
Javed I. Khan@2004

Packets & Time-Division Multiplexing



LECT-3, S-43
IN2007F, javed@kent.edu
Javed I. Khan@2004

Packets and Hardware Frames

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

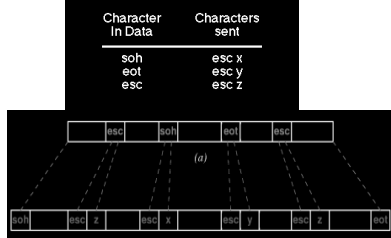
*Overhead?
What if we use
only SOH?*

soh [block of data in frame] eot

LECT-3, S-44
IN2007F, javed@kent.edu
Javed I. Khan@2004

Byte Stuffing

- What if the data contains characters that are used as control characters?



LECT-3, S-45
IN2007F, javed@kent.edu
Javed I. Khan@2004

Next Topic: Digital Trunk Lines

46

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 of error.



LECT-3, S-47
IN2007F, javed@kent.edu
Javed I. Khan@2004

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.



LECT-3, S-48
IN2007F, javed@kent.edu
Javed I. Khan@2004

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

$4865 + 6C6C + 6F20 + 776F + 726C + 642E + \text{carry} = 71FC$



LECT-3, S-49
IN2007F_javed@kent.edu
Javed I. Khan@2004

Checksum (more)

- Disadvantages: Cannot correct many common errors.

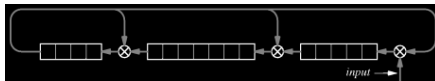
Data Item In Binary	Checksum Value	Data Item In Binary	Checksum Value
00001	1	00011	3
00010	2	00000	0
00011	3	00001	1
00001	1	00011	3
totals	7		7



LECT-3, S-50
IN2007F_javed@kent.edu
Javed I. Khan@2004

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!



LECT-3, S-51
IN2007F_javed@kent.edu
Javed I. Khan@2004

Frame Format with Error Detection



LECT-3, S-52
IN2007F_javed@kent.edu
Javed I. Khan@2004

Summary

- Until now we have seen how two computers can communicate to each other.
- Next we will see how a group of computers can be connected in a small area Network.



LECT-3, S-53
IN2007F_javed@kent.edu
Javed I. Khan@2004

Next Topic LAN