

# **A Review of Key Networking Concepts**

Raj Jain

The Ohio State University

Columbus, OH 43210

Jain@CIS.Ohio-State.Edu

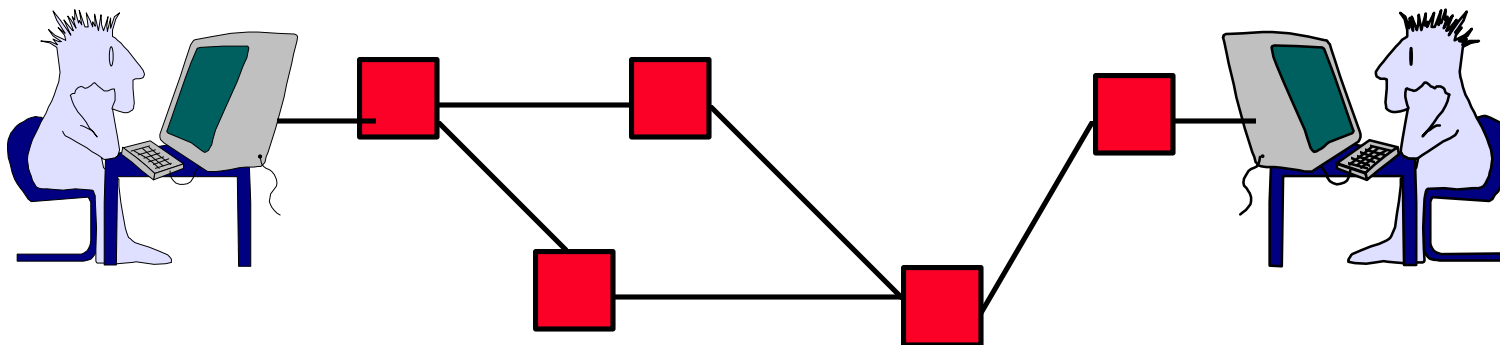
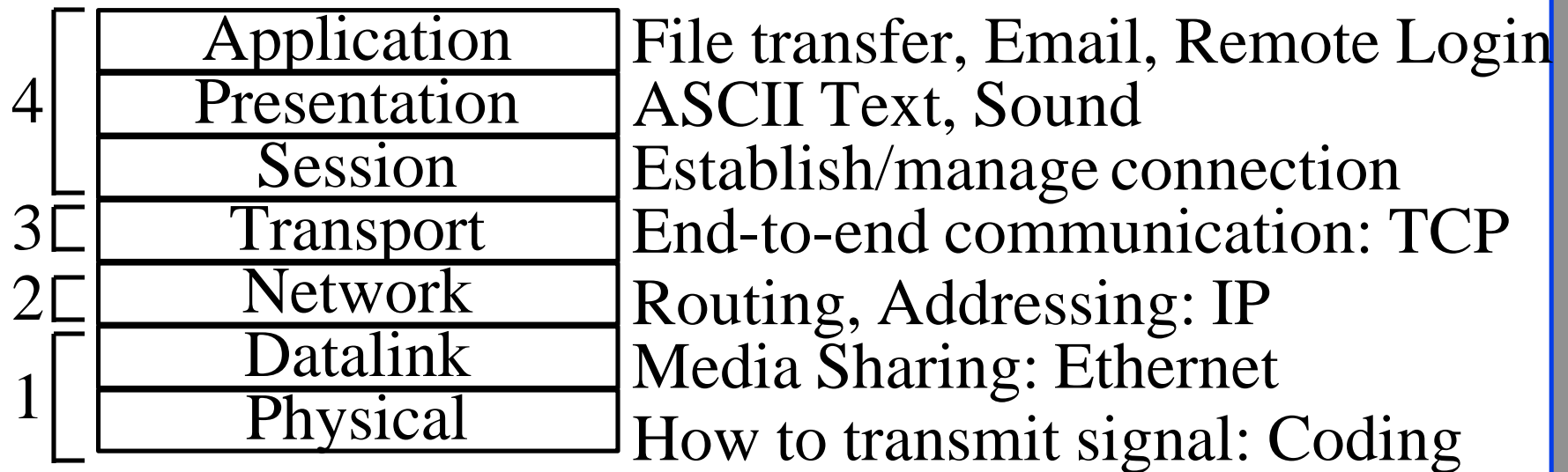
<http://www.cis.ohio-state.edu/~jain/>



- ❑ ISO/OSI Reference Model
- ❑ Ethernet/IEEE 802.3 LANs
- ❑ Interconnecting Devices

All these concepts are taught in CIS677.

# ISO/OSI Reference Model



# Layering

FTP	Telnet	Web	Email
TCP		UDP	
IP		IPX	
Ethernet		Token Ring	
Twisted Pair		Fiber	

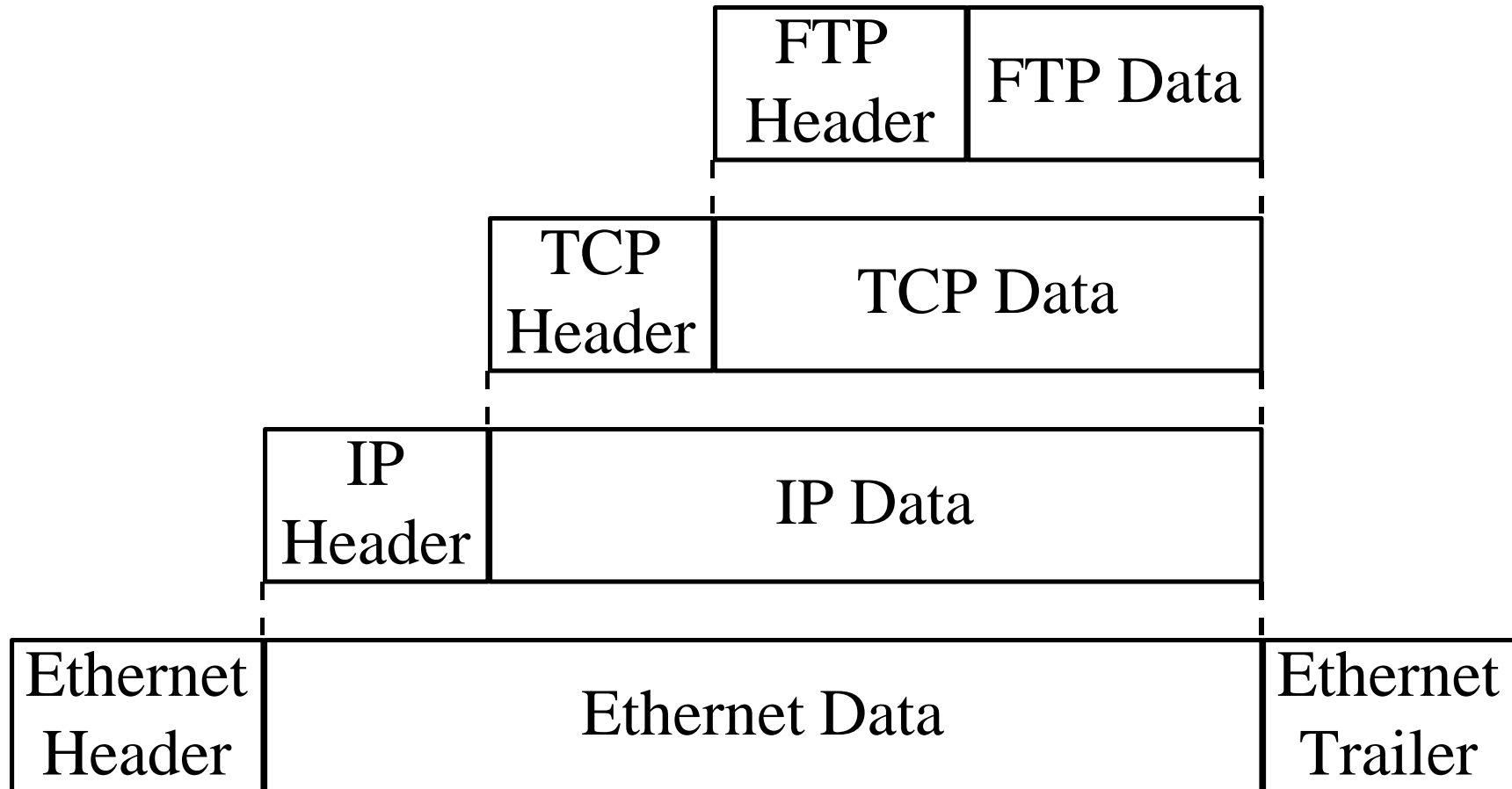
← Same Interfaces

- ❑ Protocols of each layer perform a set of functions
- ❑ All alternatives for a row have the same interfaces
- ❑ Choice of protocols at each layer is independent of those of at other layers.

UDP = User Data Protocol, TCP = Transmission Control Protocol, IPX = Internetwork Packet Exchange

# Layered Packet Format

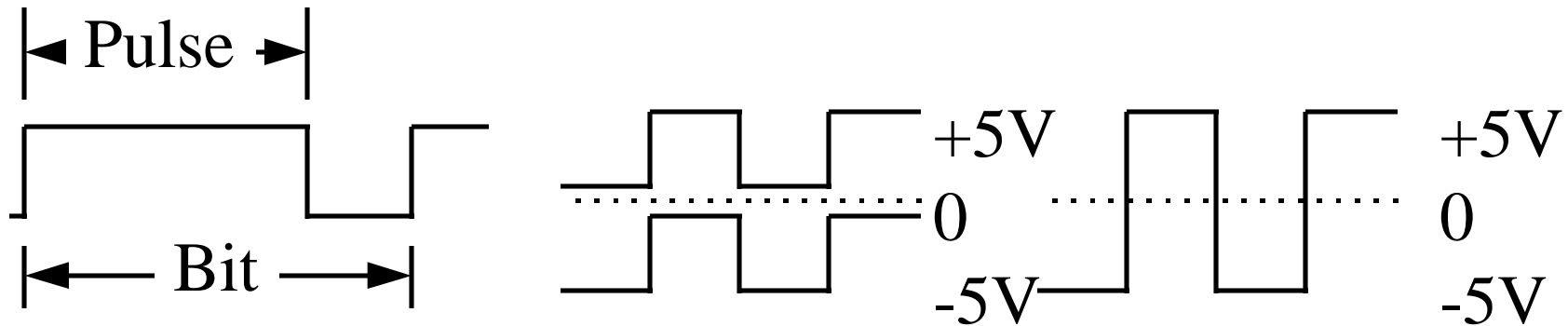
- Nth layer control info is passed as N-1th layer data.



# Transmission Media

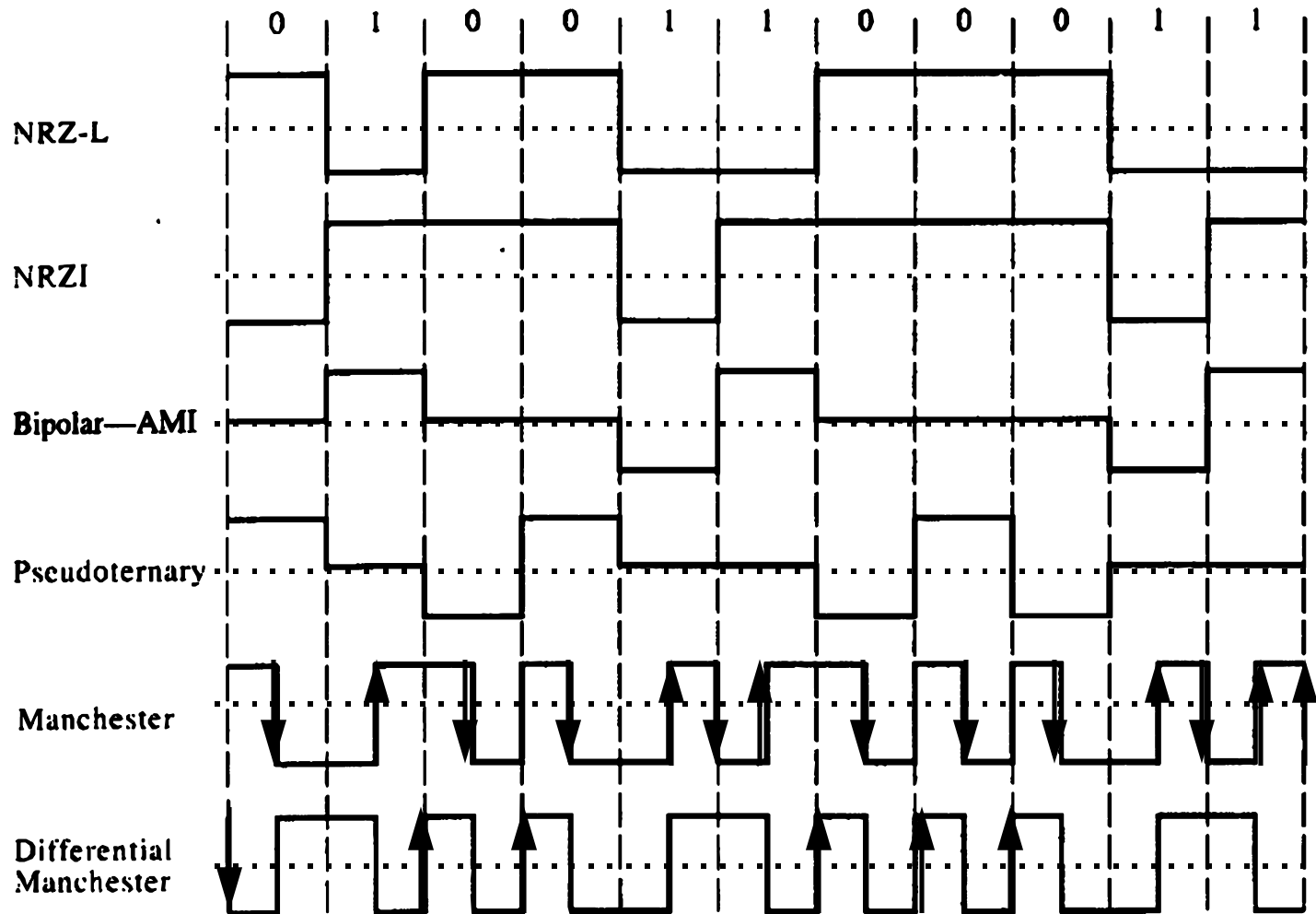
- ❑ Magnetic Media: Physically transfer data stored on a magnetic tape or floppy disk
- ❑ Guided Media: UTP, STP, Coax, Fiber

# Coding Terminology



- ❑ Signal element: Pulse
- ❑ Modulation Rate:  $1/\text{Duration of the smallest element}$   
=Baud rate
- ❑ Data Rate: Bits per second
- ❑ Data Rate =  $F_n(\text{Bandwidth, signal/noise ratio, encoding})$

# Digital Signal Encoding Formats

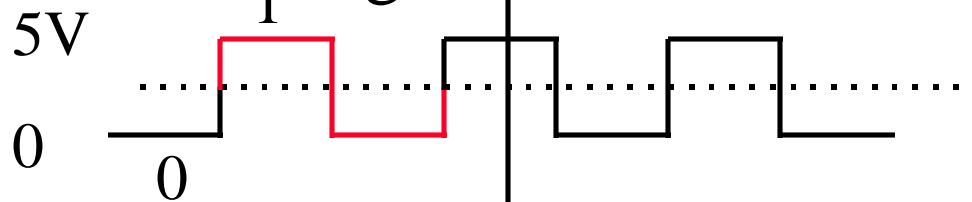


# Decibels

- Attenuation =  $\text{Log}_{10} \frac{P_{in}}{P_{out}}$  Bel
- Attenuation =  $10 \text{ Log}_{10} \frac{P_{in}}{P_{out}}$  deciBel
- Attenuation =  $20 \text{ Log}_{10} \frac{V_{in}}{V_{out}}$  deciBel Since  $P=V^2/R$
- **Example 1:**  $P_{in} = 10 \text{ mW}$ ,  $P_{out}=5 \text{ mW}$   
Attenuation =  $10 \log_{10} (10/5) = 10 \log_{10} 2 = 3 \text{ dB}$
- **Example 2:**  $P_{in} = 100\text{mW}$ ,  $P_{out}=1 \text{ mW}$   
Attenuation =  $10 \log_{10} (100/1) = 10 \log_{10} 100 = 20 \text{ dB}$

# Channel Capacity

- Capacity = Maximum data rate for a channel
- **Nyquist Theorem:** Bandwidth =  $W$   
Data rate  $\leq 2W$
- **Bilevel Encoding:** Data rate =  $2 \times$  Bandwidth



- **Multilevel Encoding:** Data rate =  $2 \times$  Bandwidth  $\times \log_2 M$



**Example:**  $M=4$ , Capacity =  $4 \times$  Bandwidth

# Shannon's Theorem

- Capacity = Bandwidth  $\times \log_2 (1 + \text{signal/noise})$
- Example: Phone wire bandwidth = 3100 Hz

$$S/N = 30 \text{ dB}$$

$$10 \text{ Log}_{10} S/N = 30$$

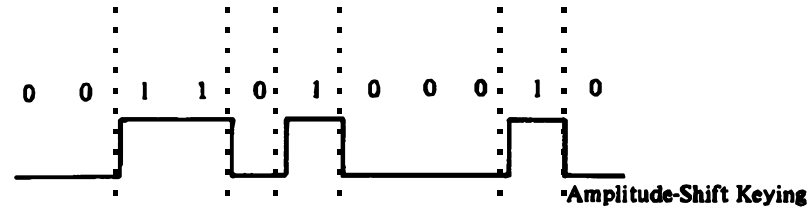
$$\text{Log}_{10} S/N = 3$$

$$S/N = 10^3 = 1000$$

$$\begin{aligned} \text{Capacity} &= 3100 \log_2 (1+1000) \\ &= 30,894 \text{ bps} \end{aligned}$$

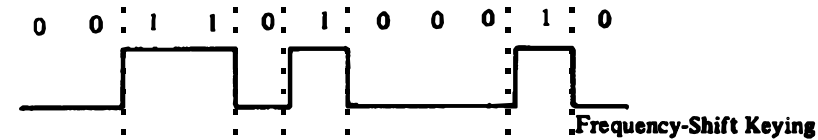
# Digital Data Analog Signals

ASK



$$A \sin(2\pi ft + \theta)$$

FSK



FSK

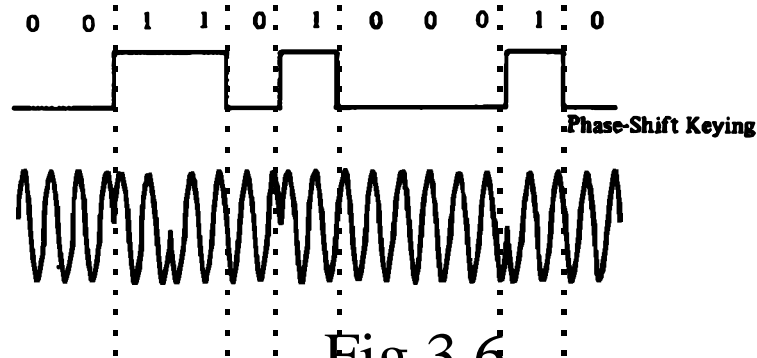


Fig 3.6

# 9600 bps Modems

- 4 bits  $\Rightarrow$  16 combinations
- 4 bits/element  $\Rightarrow$  1200 baud
- 12 Phases, 4 with two amplitudes

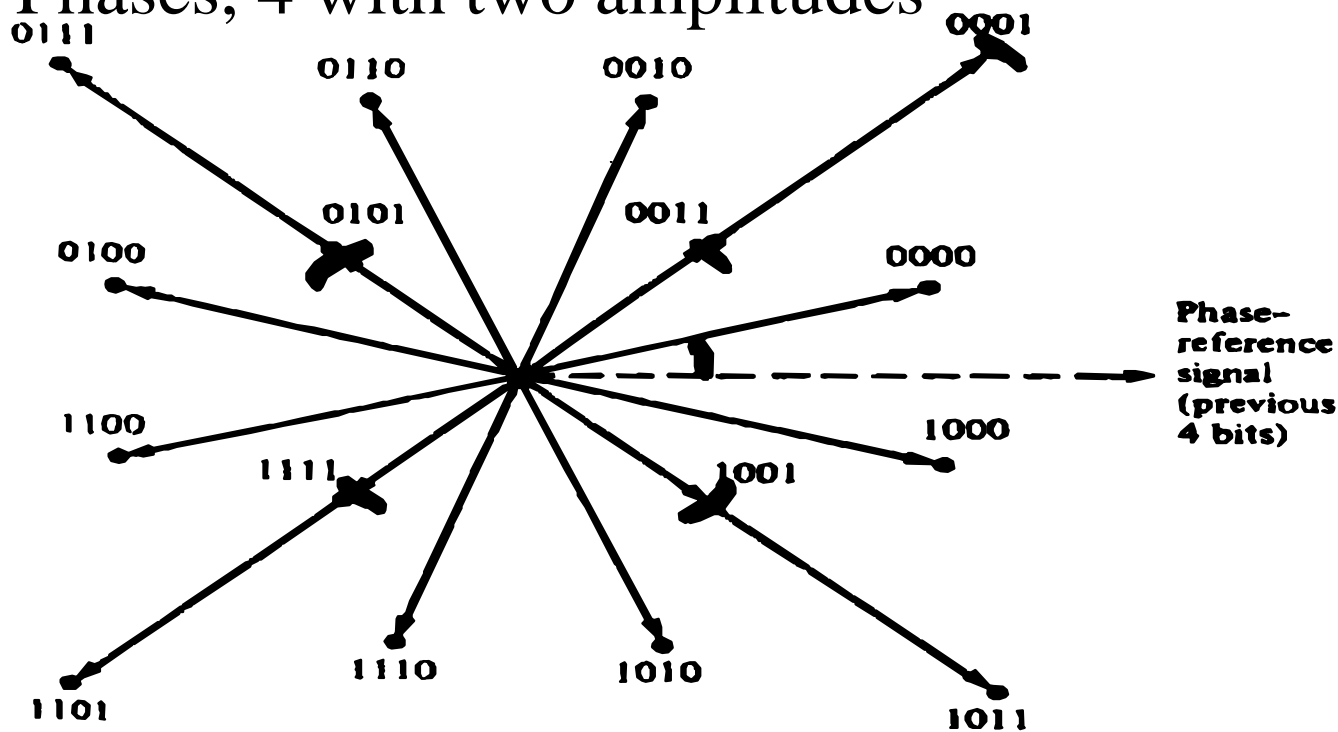


Fig 3.8

# Analog Data Digital Signal

- ❑ Sampling Theorem:  $2 \times$  Highest Signal Frequency
- ❑ 4 kHz voice = 8 kHz sampling rate  
 $8 \text{ k samples/sec} \times 8 \text{ bits/sample} = 64 \text{ kbps}$
- ❑ Quantizing Noise:  $S/N = 6n - a \text{ dB}$ ,  $n$  bits,  $a = 0$  to 1

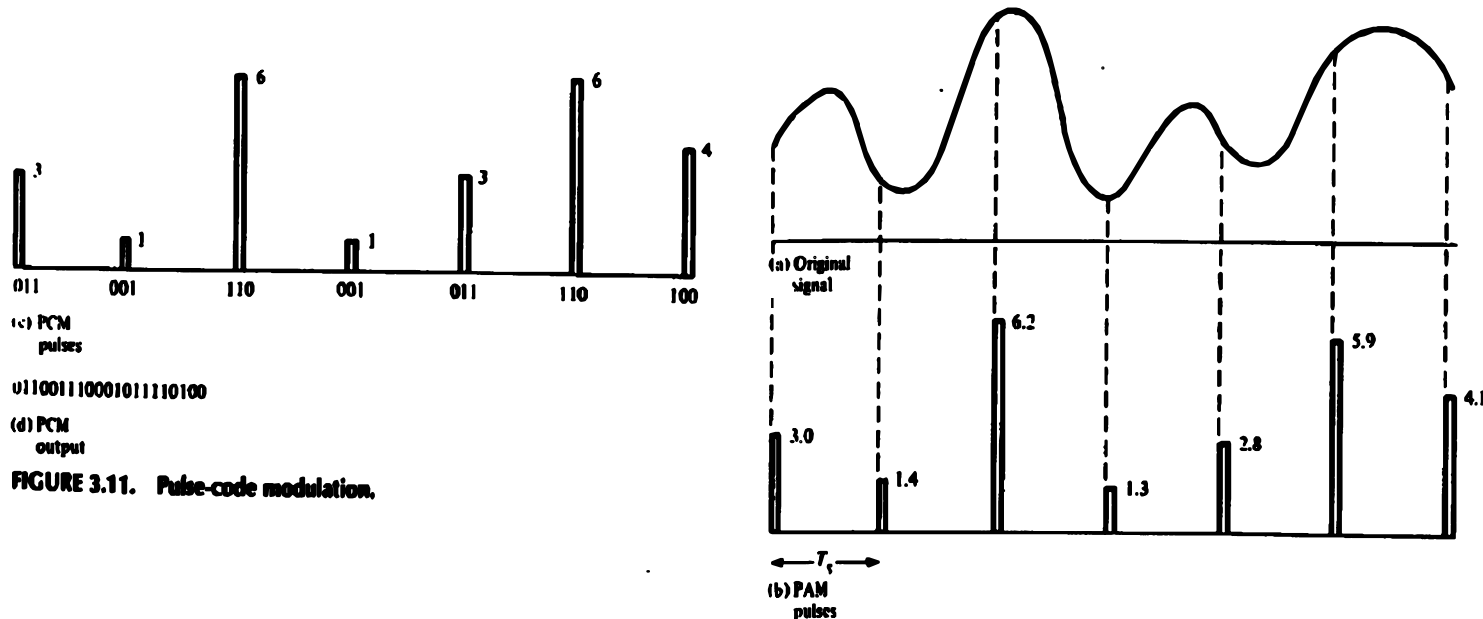


Fig 3.11

# Bit Stuffing

- ❑ Delimit with special bit pattern (bit flags)
- ❑ Stuff bits if pattern appears in data
- ❑ Remove stuffed bits at destination

(a) 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

(b) 0 1 1 0 1 1 1 1 1 0 1 1 1 1 0 1 1 1 1 1 0 1 0 0 1 0

↑  
Stuffed bits

(c) 0 1 1 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 0

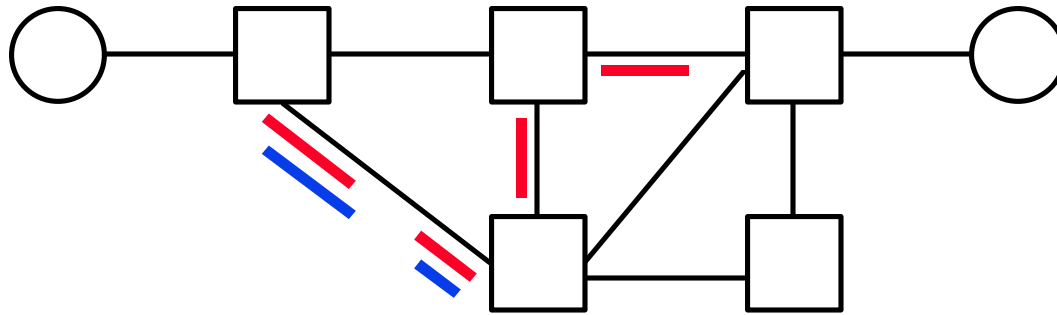
# Flow Control

- ❑ Flow Control = Sender does not flood the receiver, but maximizes throughput
- ❑ Sender throttled until receiver grants permission
- ❑ Methods:
  - ❑ Stop and wait
  - ❑ Sliding window

# Error Control

- ❑ Error Control = Deliver frames without error, in the proper order to network layer
- ❑ Error control Mechanisms:
  - ❑ Ack/Nak: Provide sender some feedback about other end
  - ❑ Time-out: for the case when entire packet or ack is lost
  - ❑ Sequence numbers: to distinguish retransmissions from originals
- ❑ ARQ: Stop and Wait, Selective Reject, Go-back n

# Connection-Oriented vs Connectionless



- ❑ Connection-Oriented: Telephone System
  - ❑ Path setup before data is sent
  - ❑ Data need not have address. Circuit number is sufficient.
- ❑ Connectionless: Postal System.
  - ❑ Complete address on each packet
  - ❑ The address decides the next hop at each router

# Multiple Access Protocols

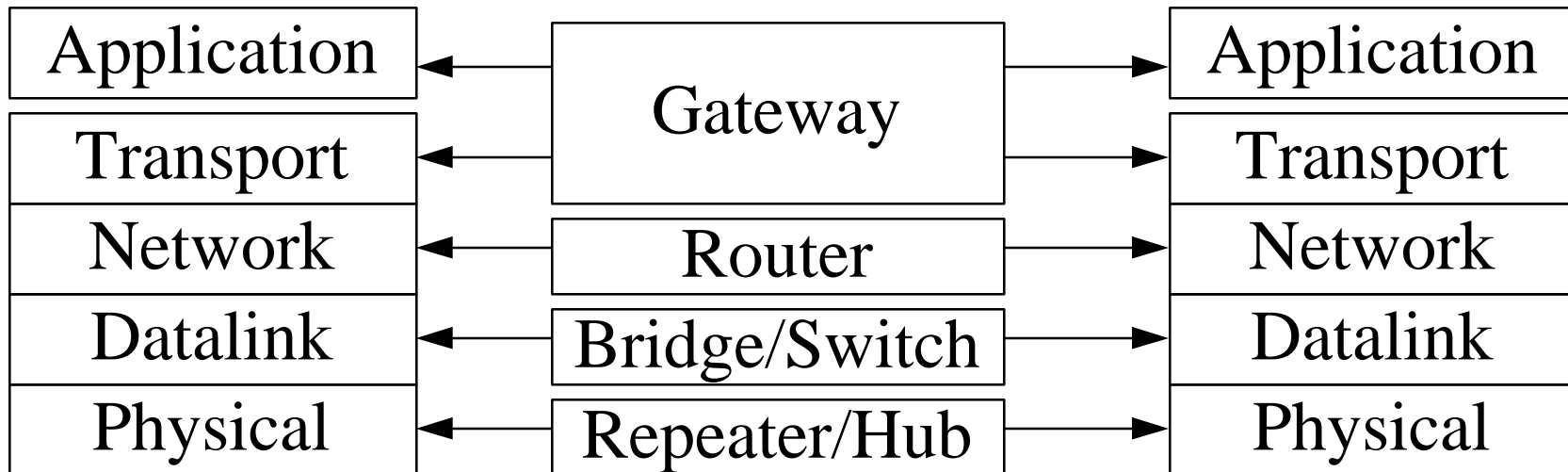
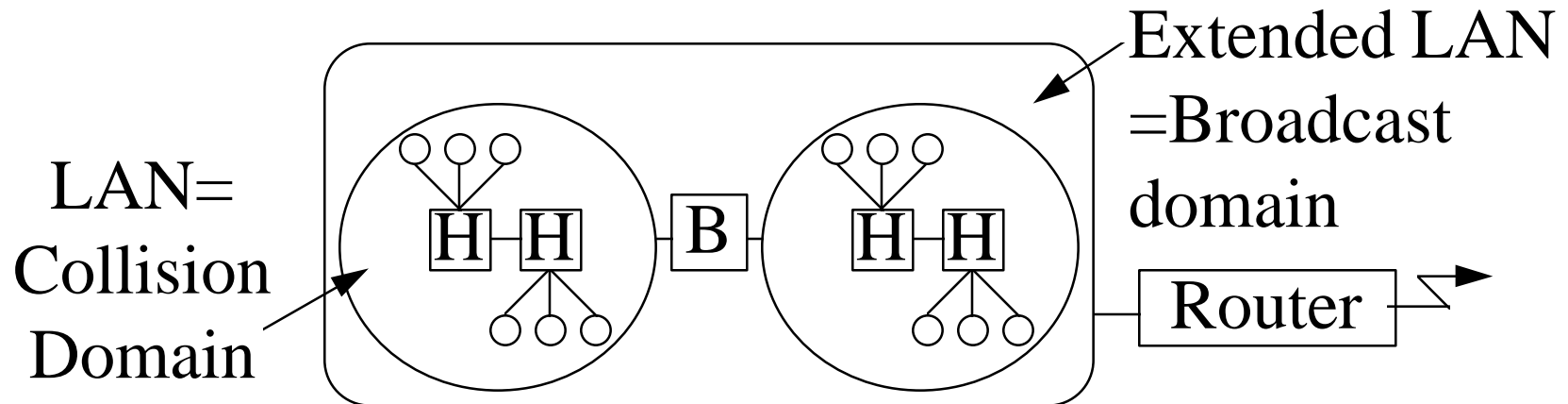
- ❑ Aloha at University of Hawaii:  
Transmit whenever you like  
Worst case utilization =  $1/(2e) = 18\%$
- ❑ CSMA: Carrier Sense Multiple Access  
Listen before you transmit
- ❑ CSMA/CD: CSMA with Collision Detection  
Listen while transmitting.  
Stop if you hear someone else.
- ❑ Ethernet uses CSMA/CD.  
Standardized by IEEE 802.3 committee.

# Interconnection Devices

- ❑ **Repeater:** PHY device that restores data and collision signals
- ❑ **Hub:** Multiport repeater + fault detection and recovery
- ❑ **Bridge:** Datalink layer device connecting two or more collision domains. MAC multicasts are propagated throughout “extended LAN.”
- ❑ **Router:** Network layer device. IP, IPX, AppleTalk. Does not propagate MAC multicasts.
- ❑ **Switch:** Multiport bridge with parallel paths

These are functions. Packaging varies.

# Interconnection Devices



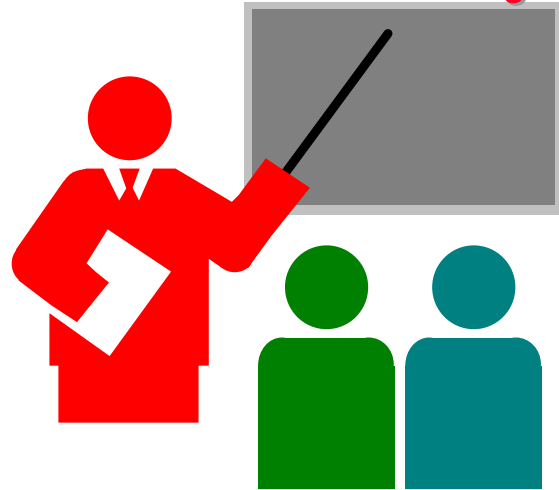
# Ethernet (IEEE 802) Address Format

- 48-bit: 1000 0000 : 0000 0001 : 0100 0011 : 0000 0000 : 1000 0000 : 0000 1100 = 80:01:43:00:80:0C

Organizationally Unique Identifier (OUI)		24 bits assigned by OUI Owner
Individual/ Group	Universal/ Local	
1	1	22
		24

- Multicast = “To all bridges on this LAN”
- Broadcast = “To all stations”  
= 111111...111 = FF:FF:FF:FF:FF:FF

# Summary



- ❑ ISO/OSI reference model has seven layers. TCP/IP Protocol suite has four layers.
- ❑ Ethernet/IEEE 802.3 uses CSMA/CD.
- ❑ Configuration rules depend upon physical medium 10Base5, 10Base2, 10Base-T, 100Base-TX, etc.
- ❑ Addresses: Local vs Global, Unicast vs Broadcast.

# Homework

- For each of the following addresses: indicate whether it is a multicast and whether it is a locally assigned address?

80:01:43:00:00:00

40:01:43:00:00:01

Were these addresses assigned by the same manufacturer?