A Review of Key Networking Concepts

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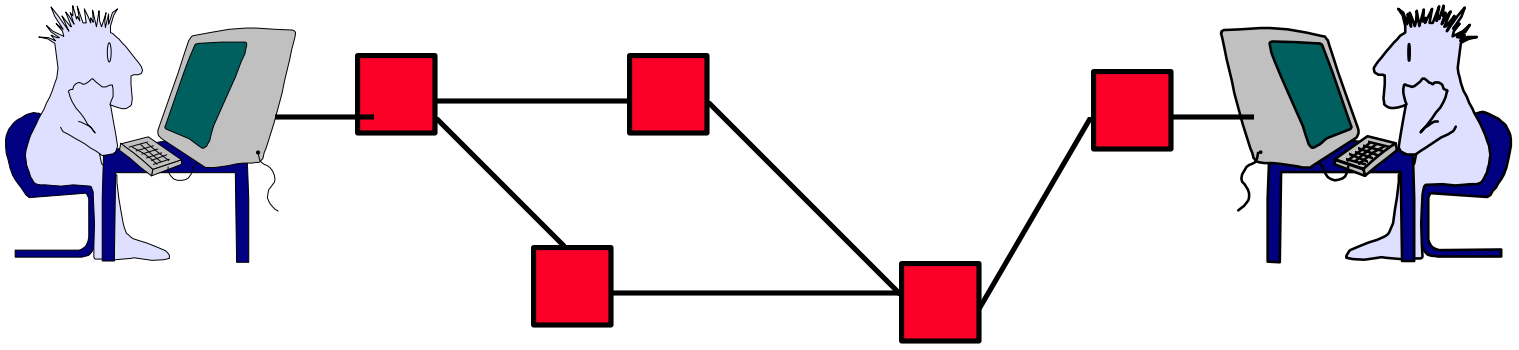
- ISO/OSI Reference Model
- Ethernet/IEEE 802.3 LANs
- Interconnecting Devices

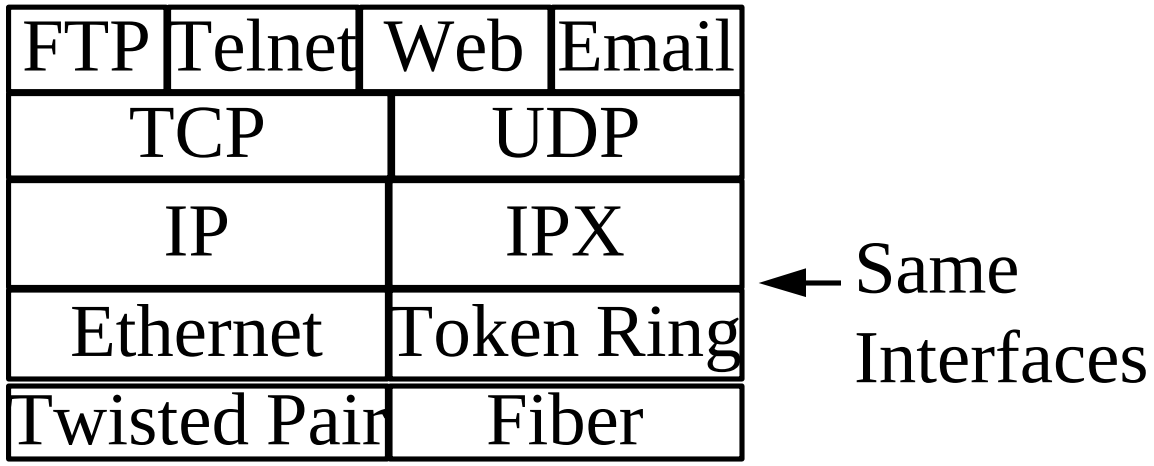
  All these concepts are taught in CIS677.

ISO/OSI Reference Model

4	Application	File transfer, Email, Remote Login
	Presentation	ASCII Text, Sound
	Session	Establish/manage connection
3	Transport	End-to-end communication: TCP
2	Network	Routing, Addressing: IP
1	Datalink	Media Sharing: Ethernet
	Physical	How to transmit signal: Coding



Layering

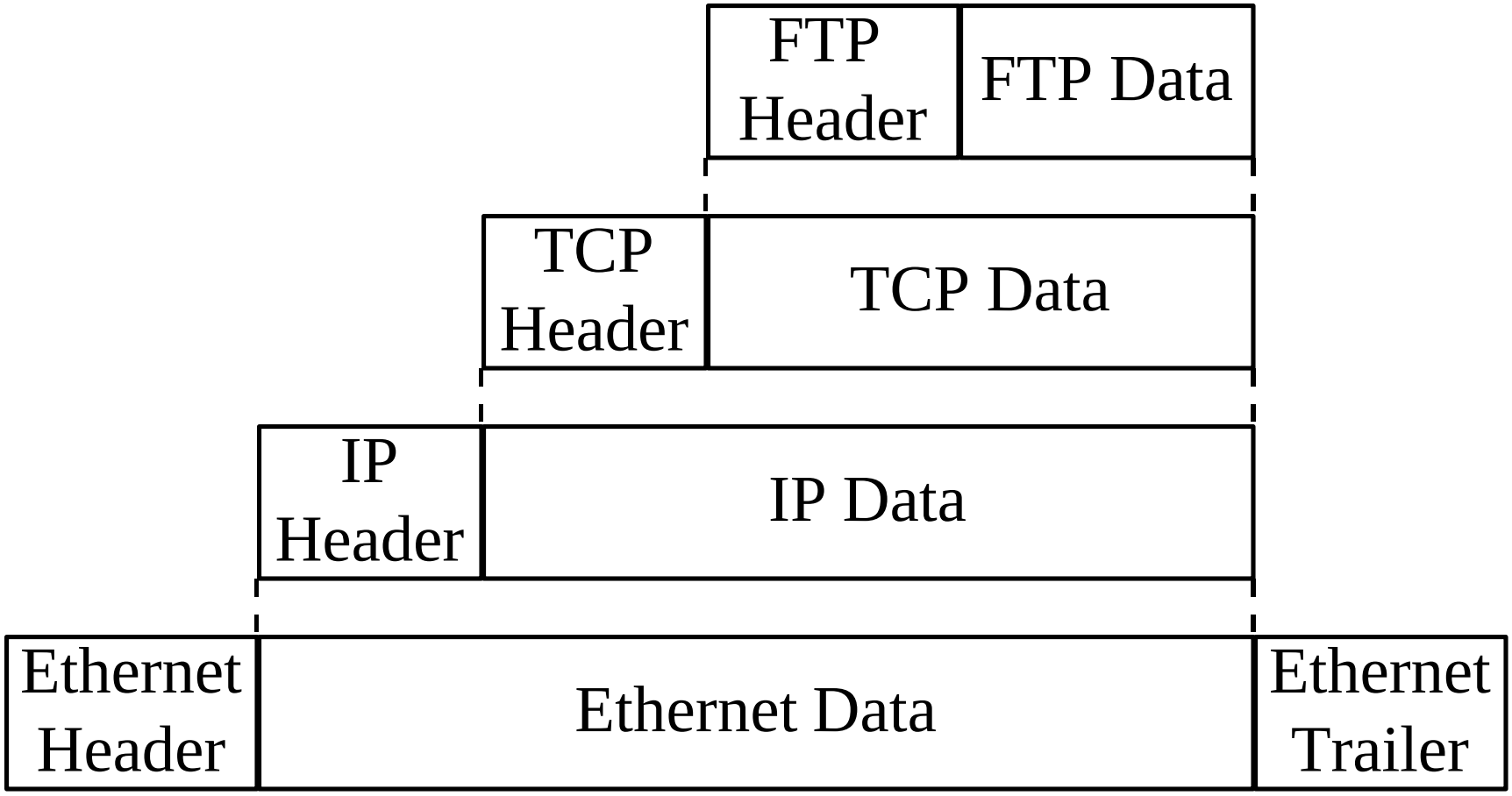


- Protocols of each layer perform a set of functions
- All alternatives for a row have the same interfaces
- Choice of protocols at each layer is independent of those of at other layers.

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

Layered Packet Format

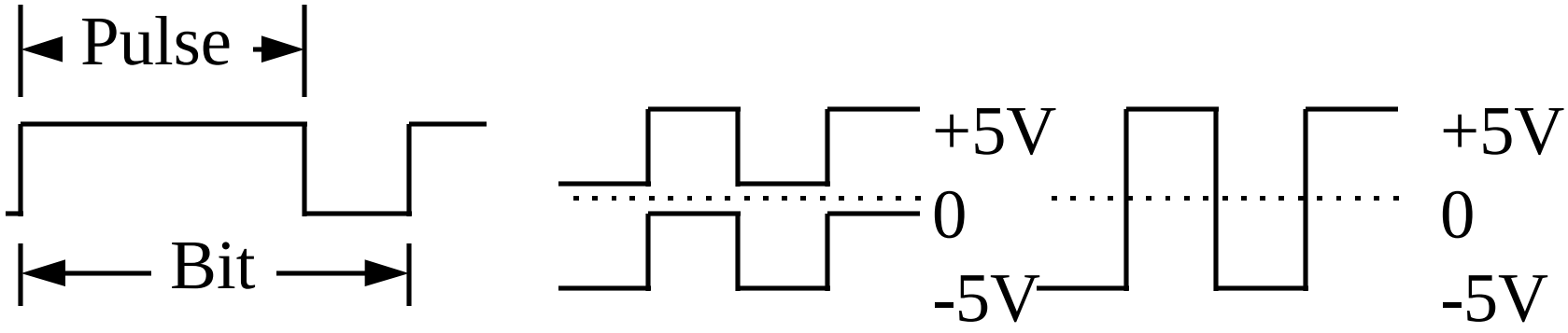
- Nth layer control info is passed as N-1th layer data.



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/Duration of the smallest element

  =Baud rate
- Data Rate: Bits per second
- Data Rate = Fn(Bandwidth, signal/noise ratio, encoding)

Digital Signal Encoding Formats

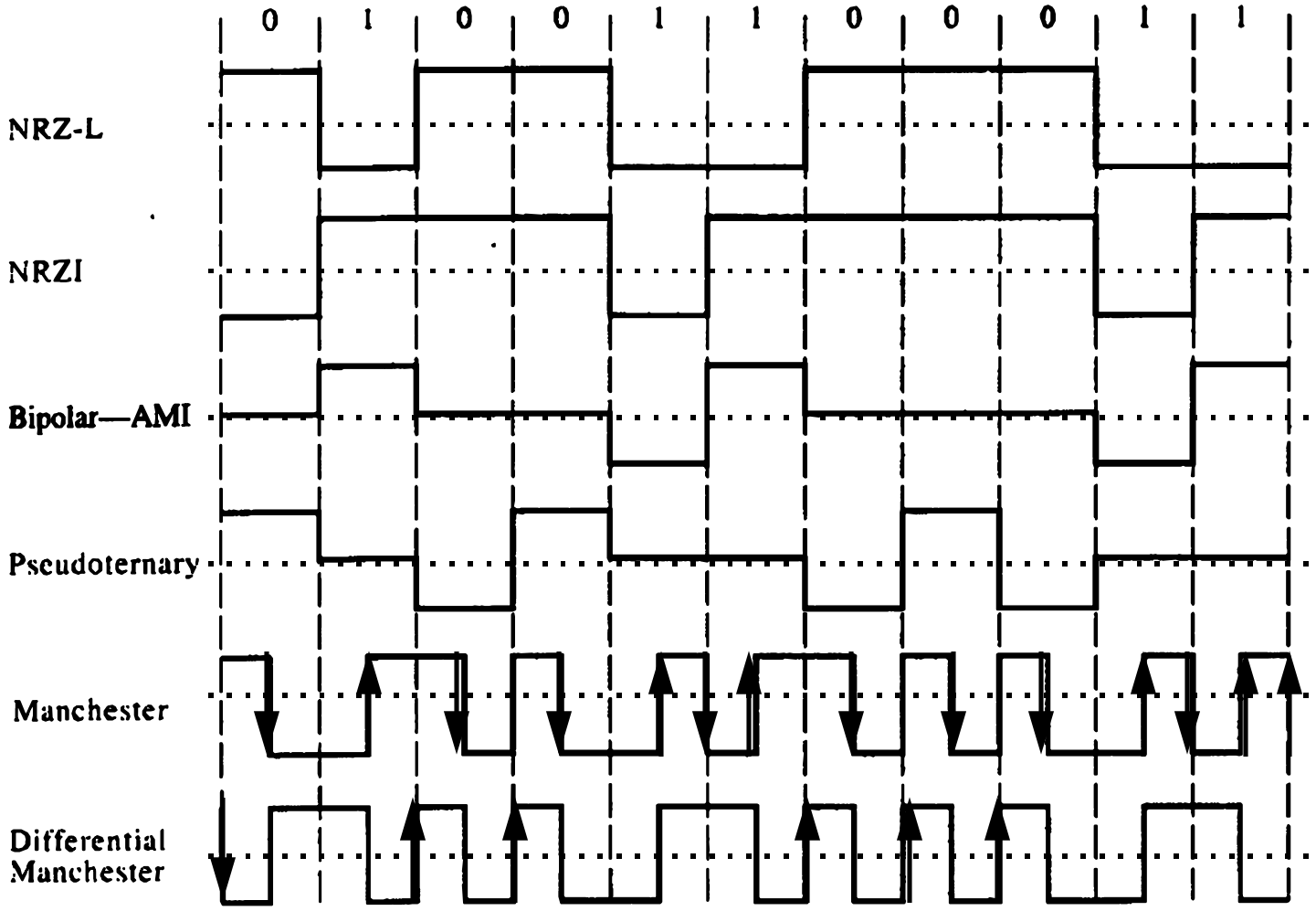


Figure3.2

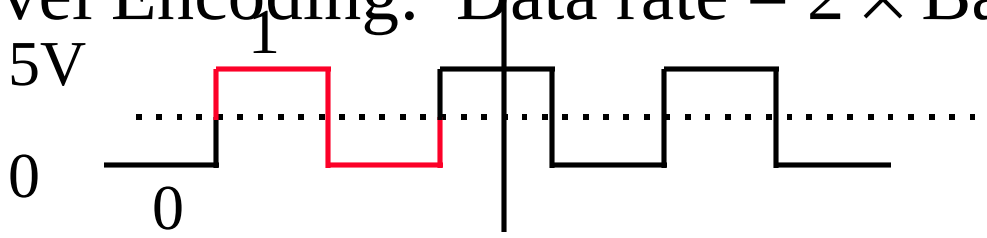
Decibels

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

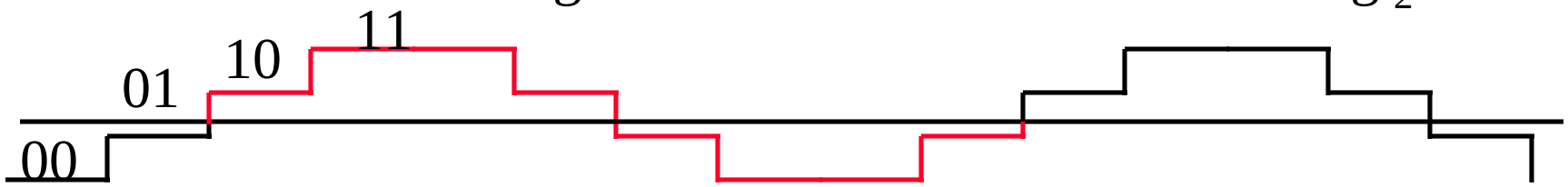
Channel Capacity

- Capacity = Maximum data rate for a channel
- **Nyquist Theorem**: Bandwidth = W

  Data rate ≤ 2 W
- 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+ signal/noise)
- Example: Phone wire bandwidth = 3100 Hz

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

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

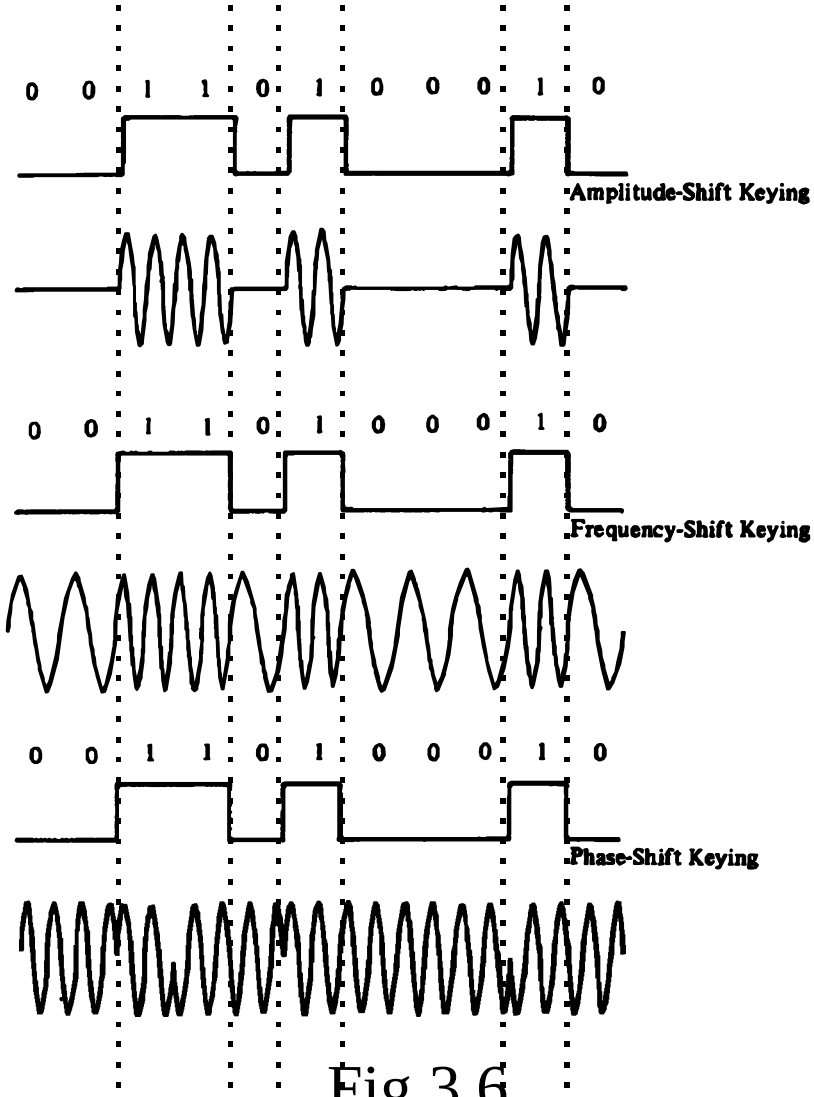
$$\text{Log}_{10} S/N = 3$$

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

$$\text{Capacity} = 3100 \log_2 (1+1000)$$

$$= 30{,}894 \text{ bps}$$

Digital Data Analog Signals



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

Fig 3.6

9600 bps Modems

- 4 bits ⇒ 16 combinations
- 4 bits/element ⇒ 1200 baud
- 12 Phases, 4 with two amplitudes

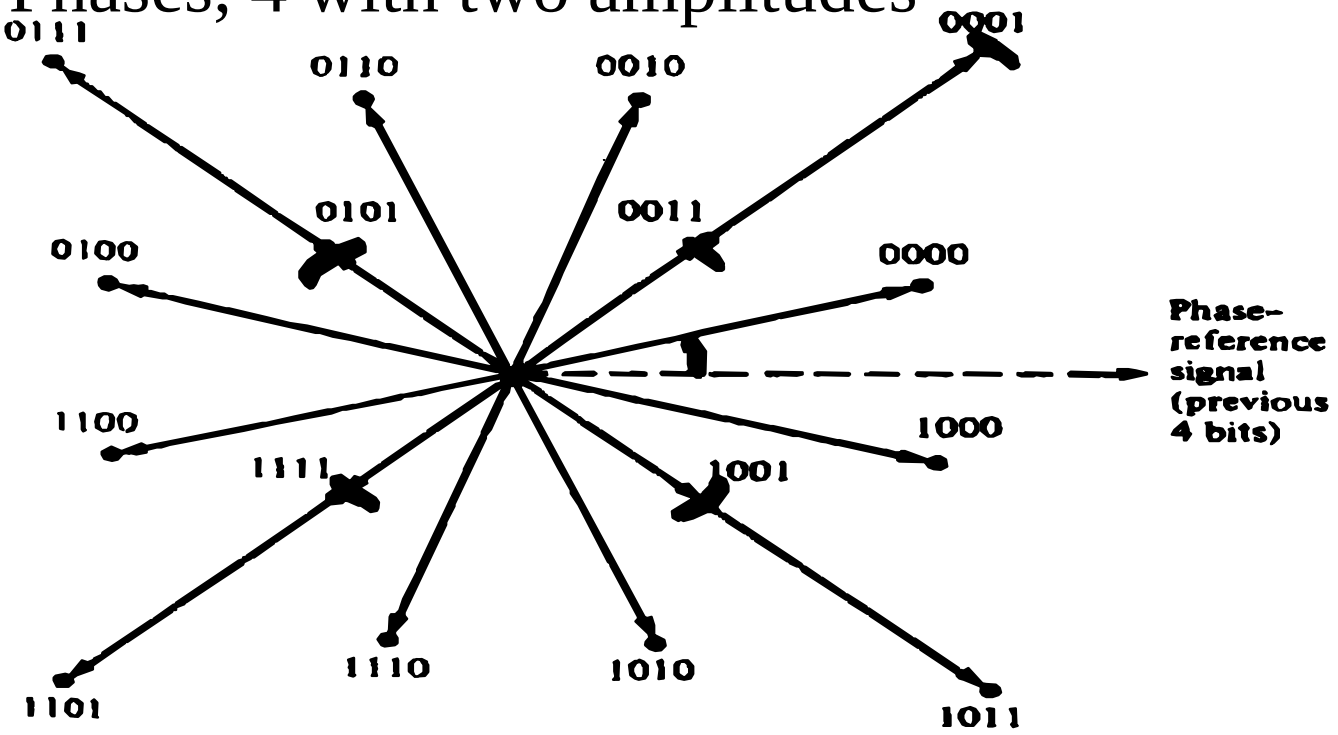


Fig 3.8

Analog Data Digital Signal

- Sampling Theorem: 2 × Highest Signal Frequency
- 4 kHz voice = 8 kHz sampling rate
  8 k samples/sec × 8 bits/sample = 64 kbps
- Quantizing Noise: S/N = 6*n* - *a* dB, *n* bits, *a* = 0 to 1

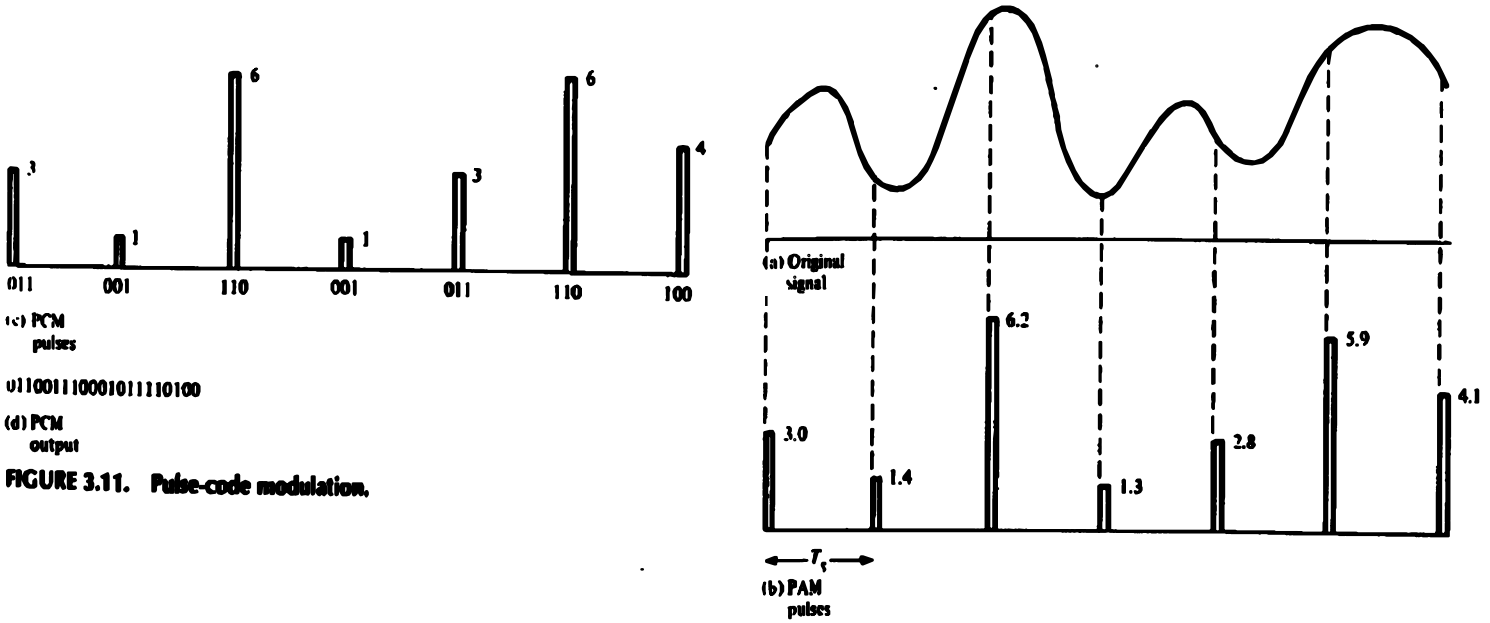


FIGURE 3.11. Pulse-code modulation.

Fig 3.11

Bit Stuffing

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

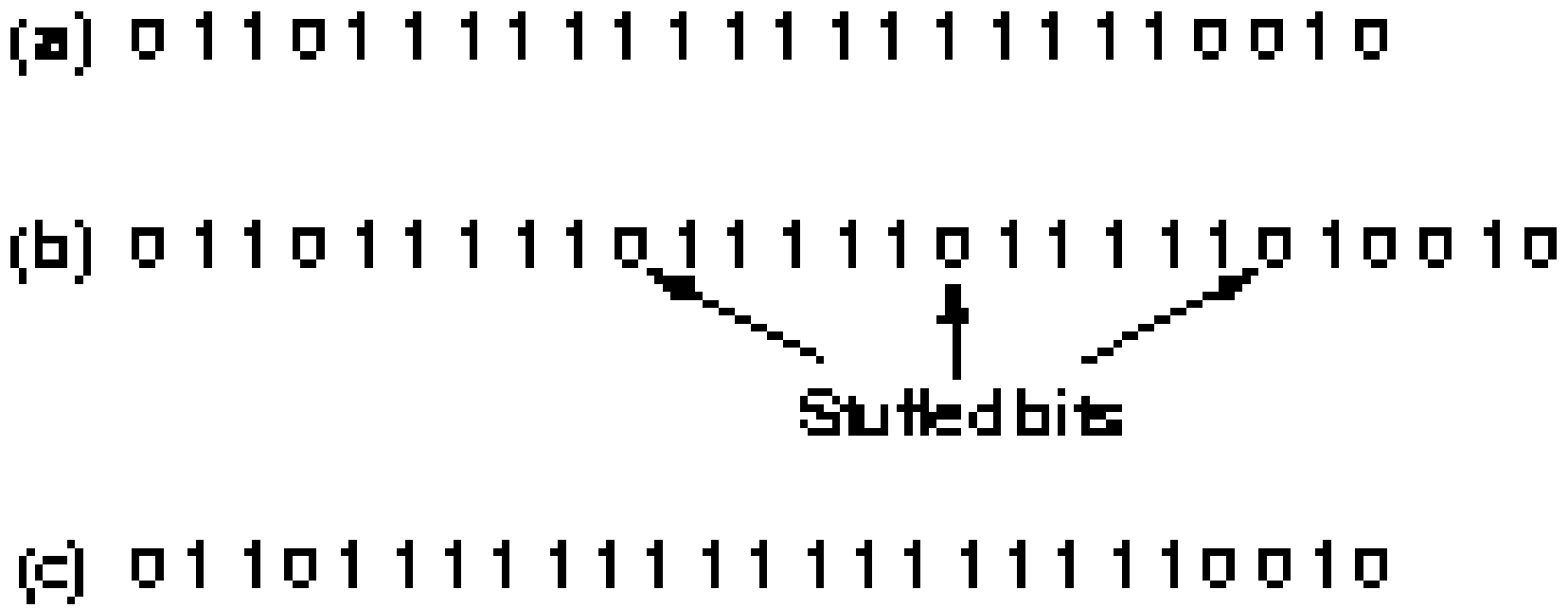


Fig 3-5

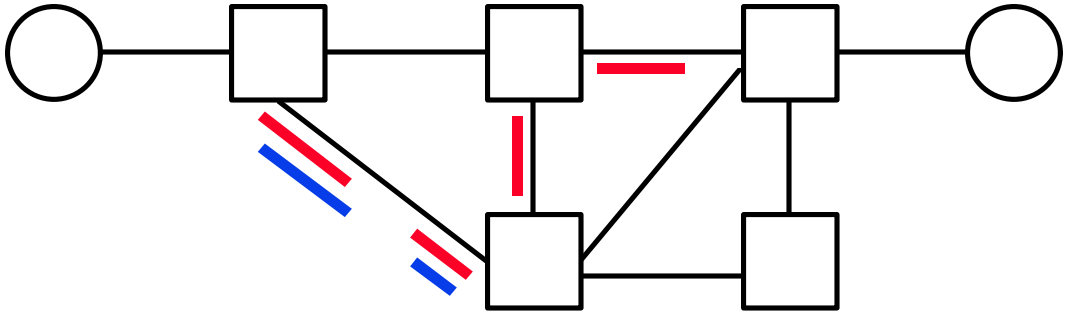
Flow Control

- 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

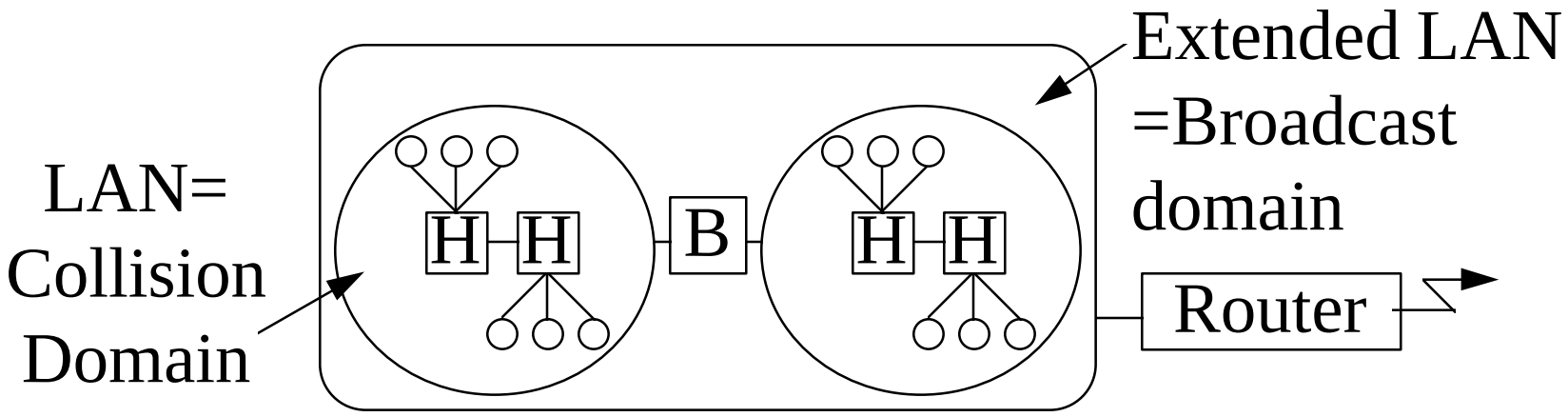
- Aloha at University of Hawaii:
  Transmit whenever you like
  Worst case utilization = 1/(2e) =18%
- CSMA: Carrier Sense Multiple Access
  Listen before you transmit
- CSMA/CD: CSMA with Collision Detection
  Listen while transmitting.
  Stop if you hear someone else.
- Ethernet uses CSMA/CD.
  Standardized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

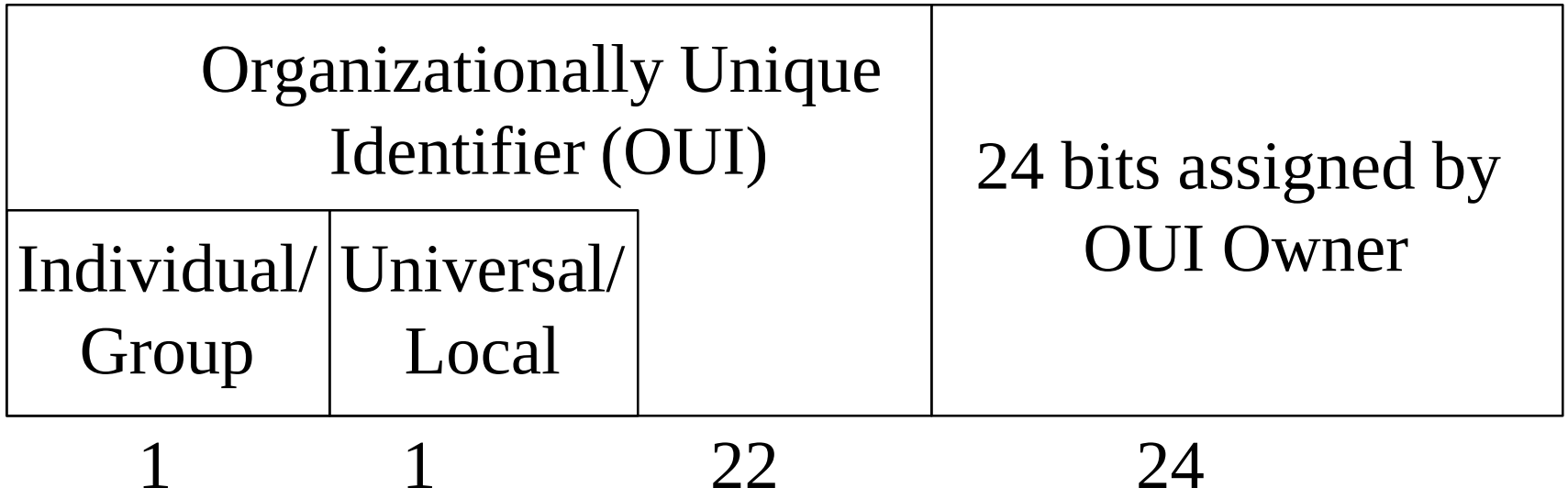
Interconnection Devices



Application	Gateway	Application
Transport		Transport
Network	Router	Network
Datalink	Bridge/Switch	Datalink
Physical	Repeater/Hub	Physical

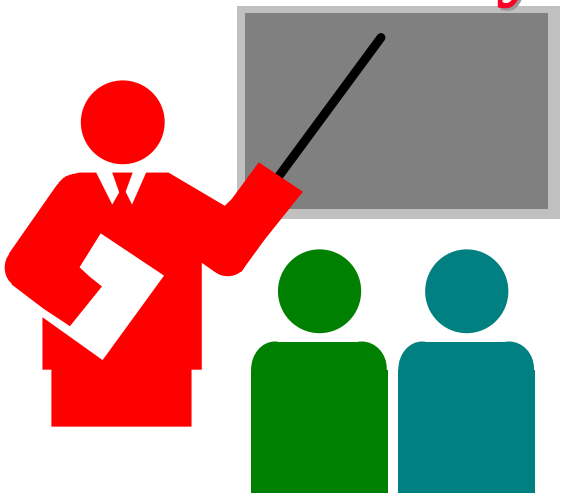
Ethernet (IEEE 802) Address Format

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



- 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?