A Review of Key Networking Concepts

Raj Jain

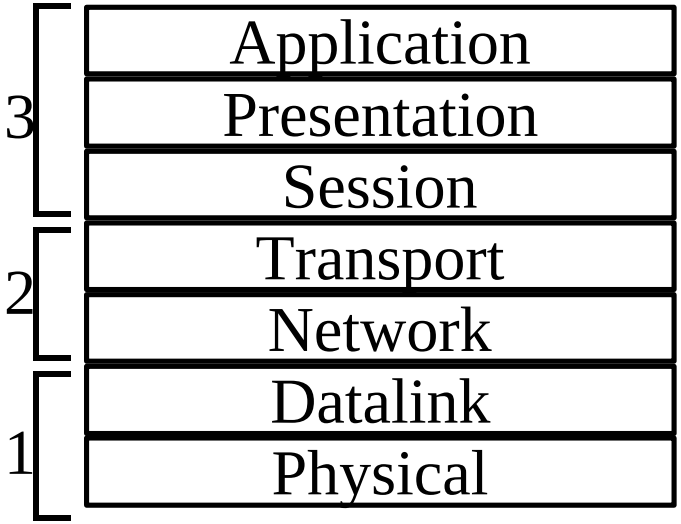
Raj Jain is now at
Washington University in Saint Louis
Jain@cse.wustl.edu
http://www.cse.wustl.edu/~jain/

Overview

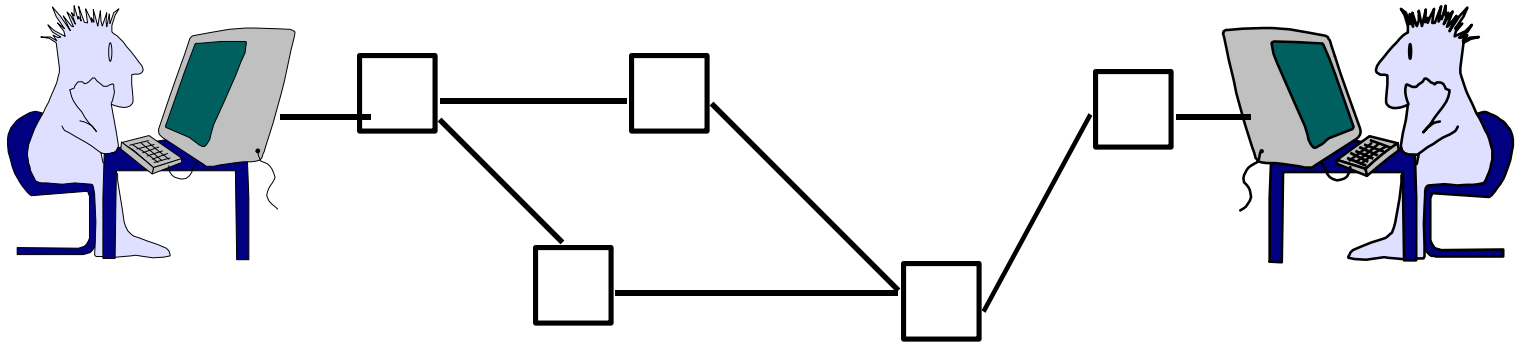
- ISO/OSI Reference Model
- Ethernet/IEEE 802.3 LANs
- Interconnecting Devices

  All these concepts are taught in CIS677.

ISO/OSI Reference Model

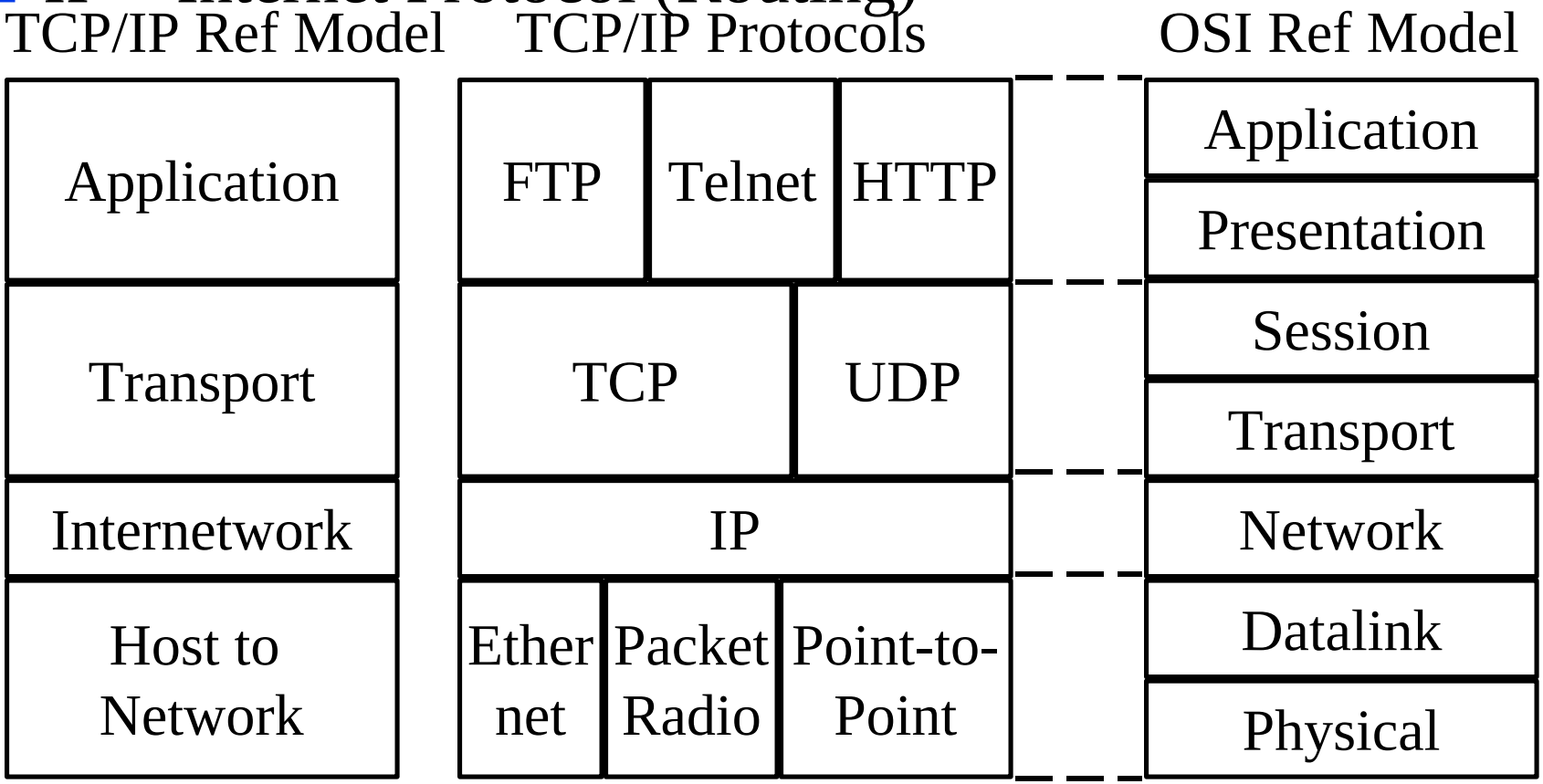


File transfer, Email, Remote Login
ASCII Text, Sound
Establish/manage connection
End-to-end communication: TCP
Routing, Addressing: IP
Two party communication: Ethernet
How to transmit signal: Coding



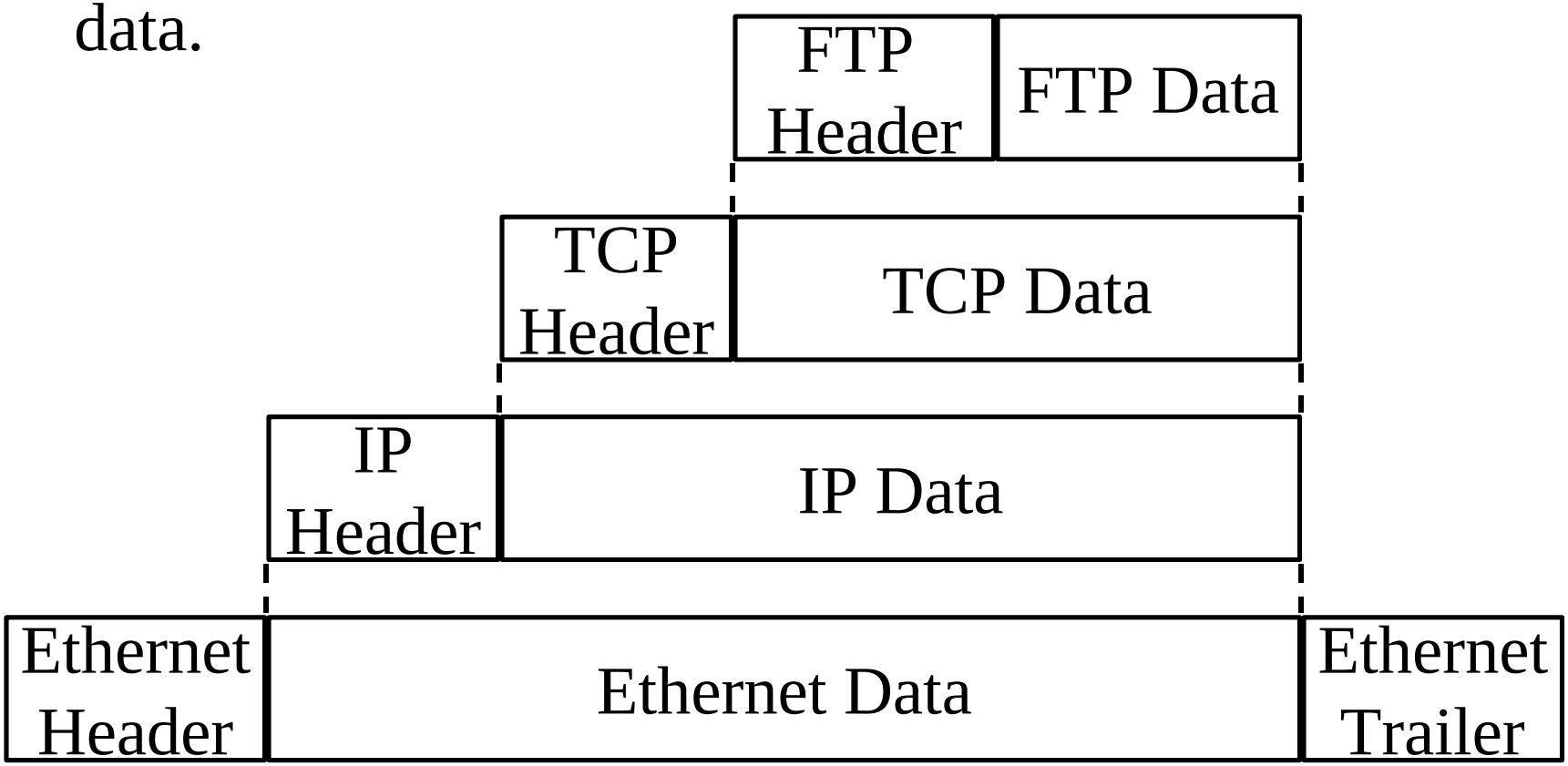
TCP/IP Reference Model

- TCP = Transport Control Protocol
- IP = Internet Protocol (Routing)

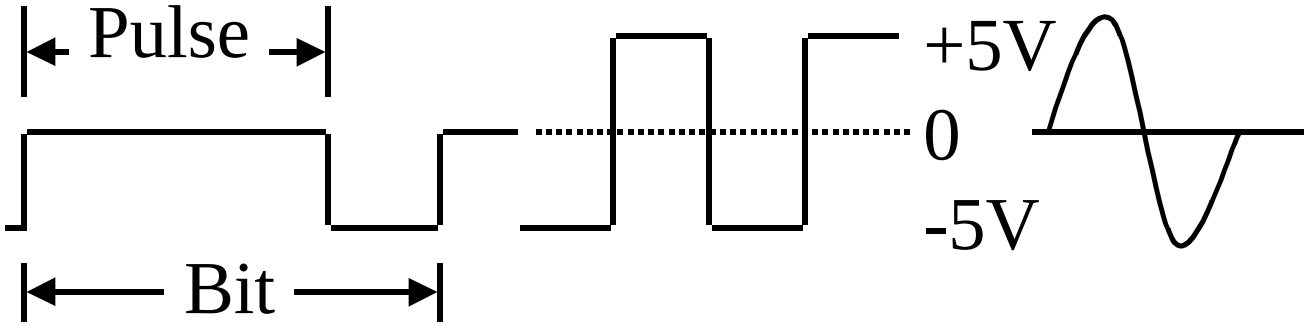


Layered Packet Format

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



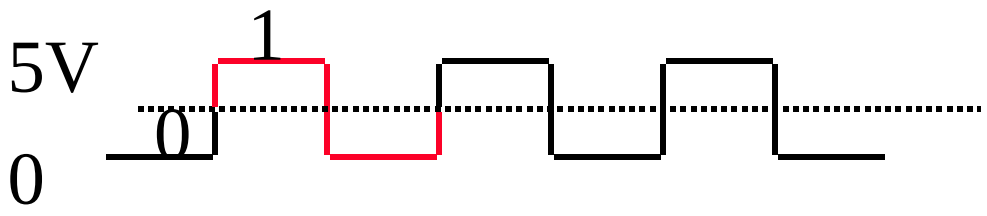
Coding Terminology



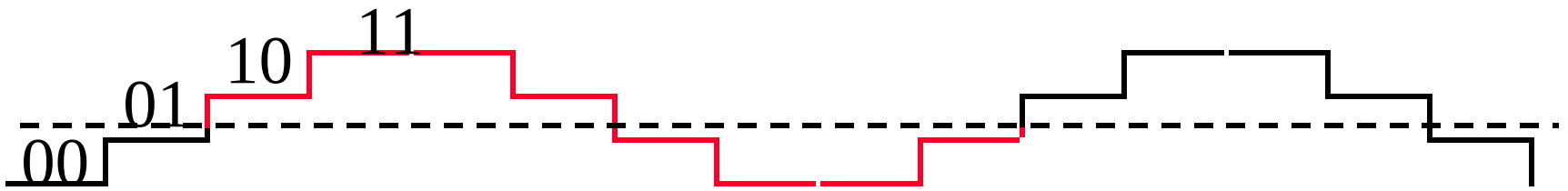
- Signal element: Pulse
- Modulation Rate: 1/Duration of the smallest element
  =Baud rate
- Data Rate: Bits per second
- Data Rate = Fn(Bandwidth, signal/noise ratio, encoding)

Channel Capacity

- Capacity = Maximum data rate for a channel
- **Nyquist Theorem**:
- Bilevel Encoding: Data rate = 2 × Bandwidth



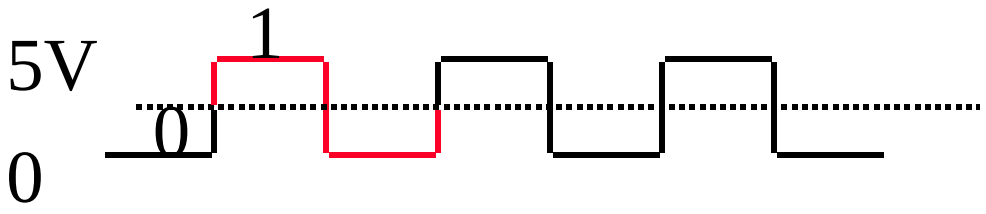
- Multilevel coding: Data rate = 2 × Bandwidth × $\log_2$ M



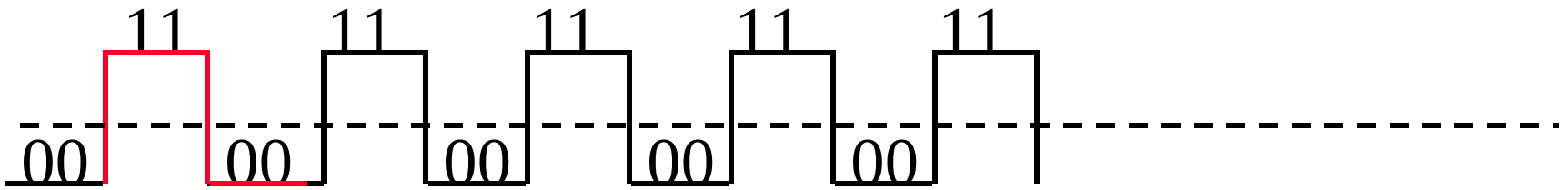
Example: M=4, Capacity = 4 × Bandwidth

Channel Capacity (Cont)

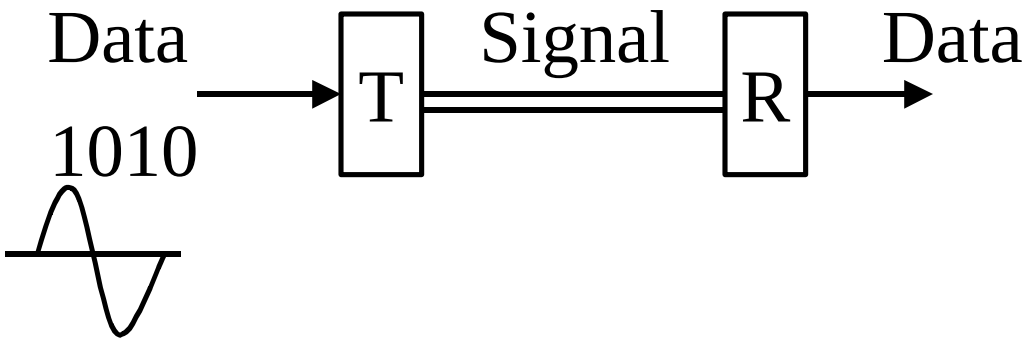
- Bilevel Encoding: Worst case: 1010101010
  Cycle time = 2 × Bit time
  ⇒ Data rate = 2 × Bandwidth



- Multilevel coding: Worst case 0011001100110011
  Cycle time = 4 × Bit time
  ⇒ Data rate = 2 × Bandwidth × $\log_2$ M



Data vs Signal

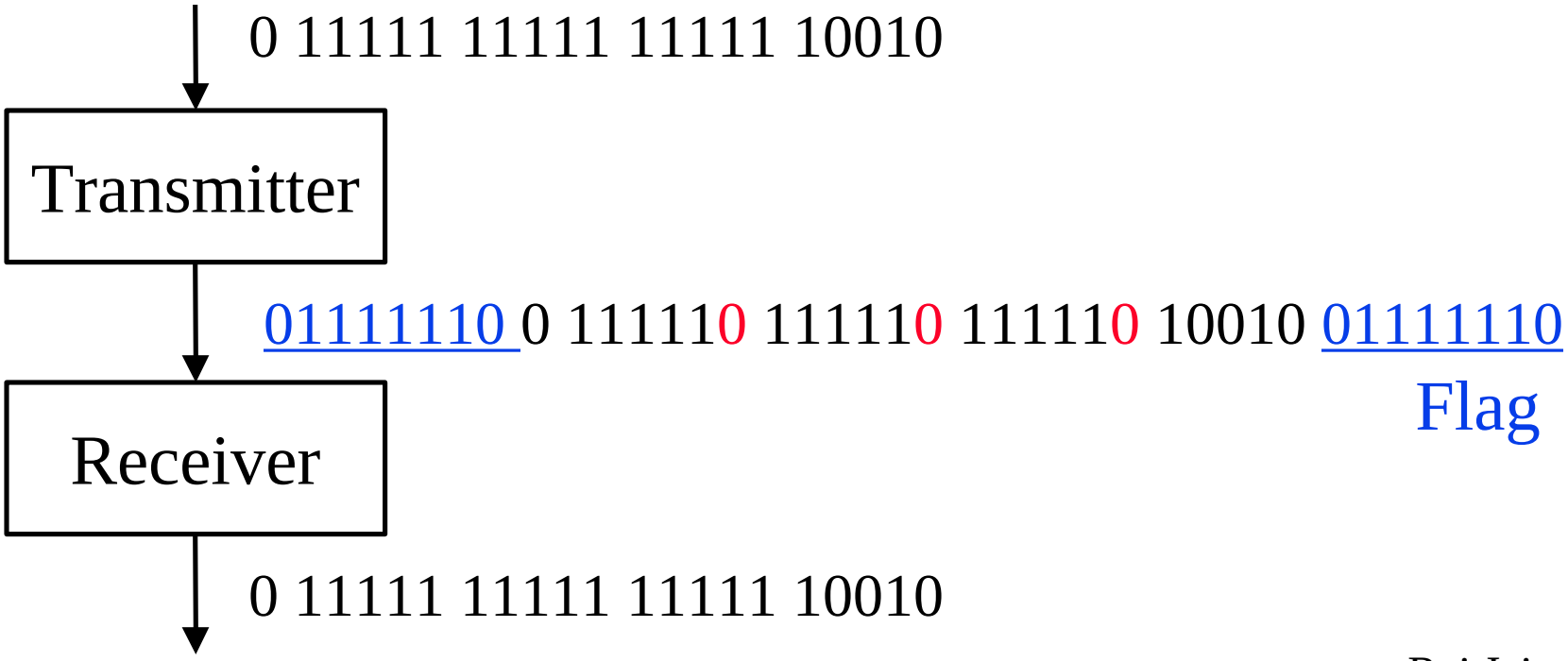


- Data: Analog (Music), Digital (files)
- Signal: Analog (POTS, Radio), Digital (ISDN)

Data	Signal		Examples
Analog	Analog	Modulation	AM, FM
Digital	Analog	Coding/Keying	ASK, FSK, PSK
Analog	Digital	Modulation	PCM, ADPCM
Digital	Digital	Coding	Manchester, NRZ

Bit Stuffing

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



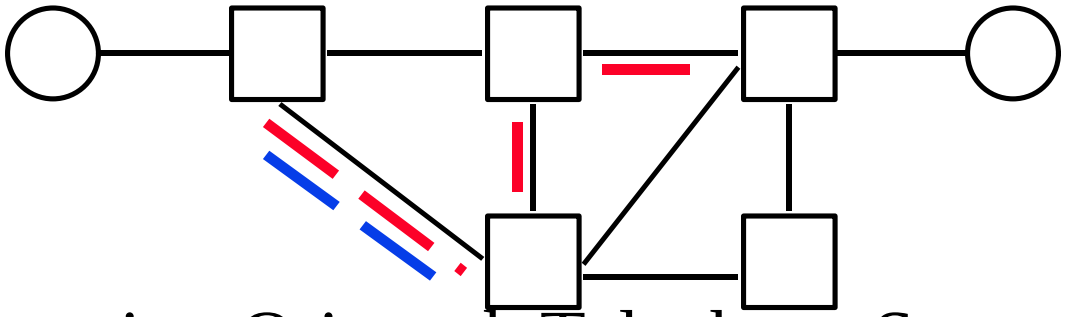
Flow Control

- 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

(a) Multiple Access

(b) Carrier-Sense Multiple Access with Collision Detection

Multiple Access Protocols

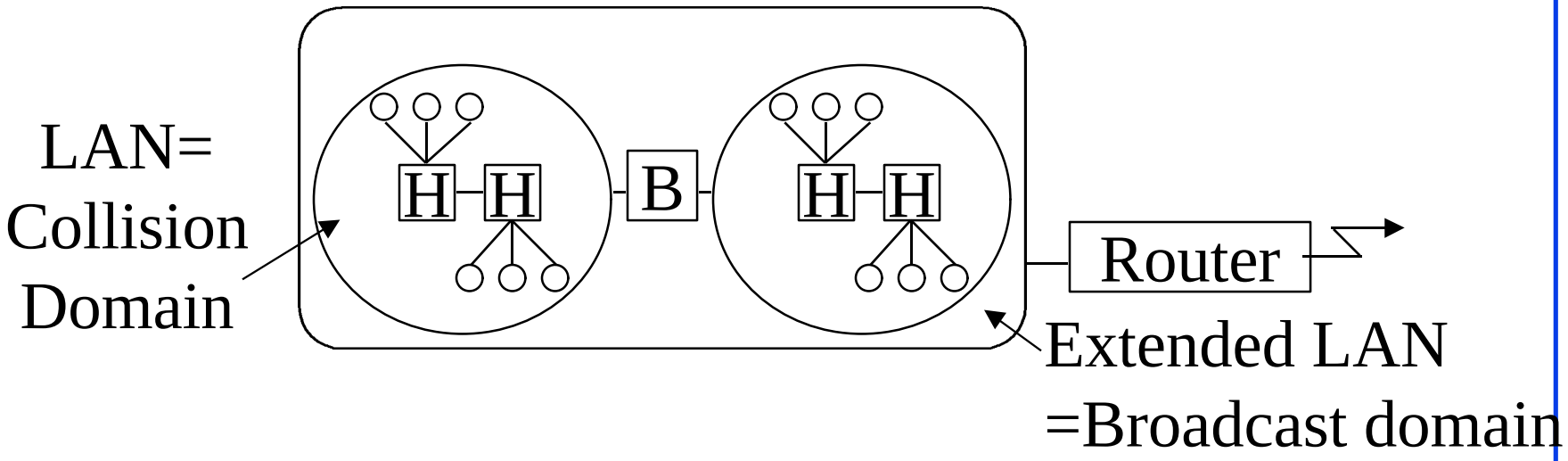
- Aloha at University of Hawaii:
  Transmit whenever you like
  Worst case utilization = 1/(2e) =18%
- CSMA: Carrier Sense Multiple Access
  Listen before you transmit
- CSMA/CD: CSMA with Collision Detection
  Listen while transmitting.
  Stop if you hear someone else.
- Ethernet uses CSMA/CD.
  Standardized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

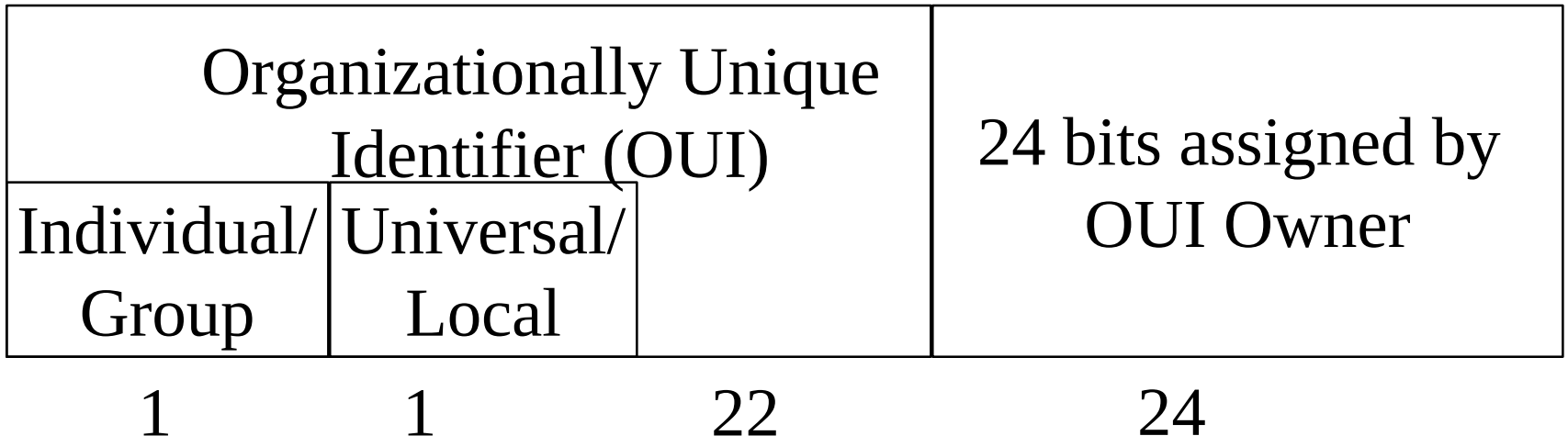
Interconnection Devices



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

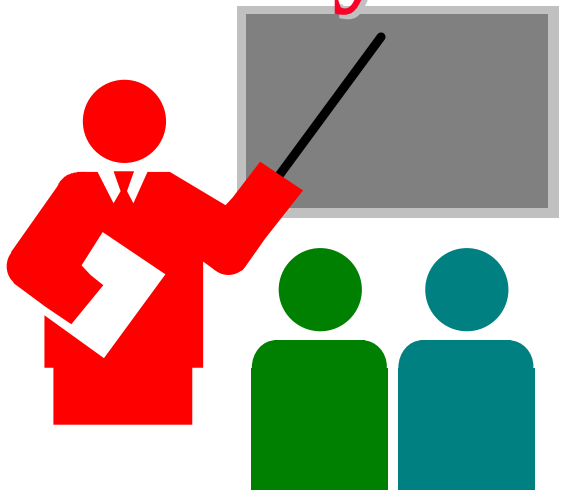
IEEE 802 Address Format

- 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.
- 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?
  80:03:45:00:00:00
  40:03:45:00:00:01
  Were these addresses assigned by the same manufacturer?

- Due: Next week