Networking Basics

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Overview

- Standards Organizations
- ISO/OSI and TCP/IP Reference Model
- Flow and Error Control
- Ethernet, HDLC, PPP
- Internet Protocol (IP), IPv6
- TCP
- Domain Name System

International Standards Organizations

- ISO: International Standards Organization
  Chartered by United Nations
- ITU: International Telecommunications Union
  - ITU-T: Consultative Committee on International Telephone and Telegraph (CCITT)
  - ITU-R: Consultative Committee on International Radio (CCIR)
  - Example Standards: G.724, X.25, Q.931
  - www.itu.ch
- IEC: International Electrotechnical Commission

National Standards Organizations

- ANSI: American National Standards Institute
  - www.ansi.org
  - Non-governmental, nonprofit, over 300 committees
  - ANSI T1.105-1995 SONET
    ANSI X3.131-1994 SCSI-2
  - Represents USA in ITU, IEC, and ISO

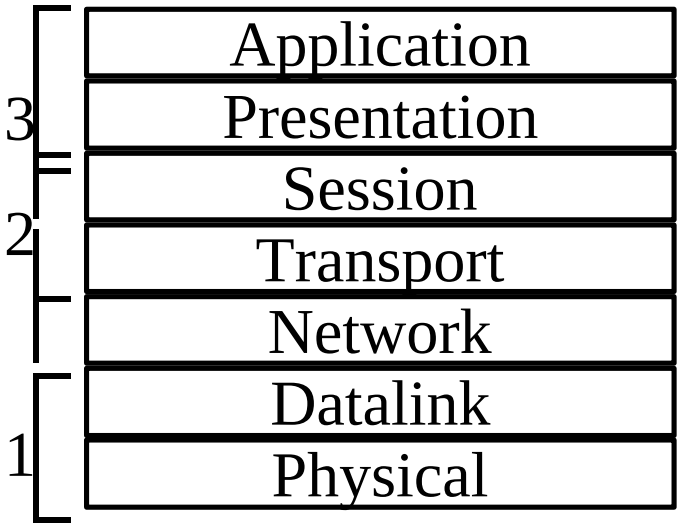
Professional Associations

- IEEE: Inst of Electrical and Electronic Engineers,
  - standards.ieee.org
  - IEEE ⇒ ISO (via ANSI)
  - Ethernet ⇒ IEEE 802.3 ⇒ ISO 8802-3:1998
- EIA: Electronic Industries Association, www.eia.org
  - Example: EIA-232 (RS-232)
- TIA: Telecommunications Industries Association,
  - www.tiaonline.org
- ATM Forum, www.atmforum.com
- Frame Relay Forum, www.frforum.com

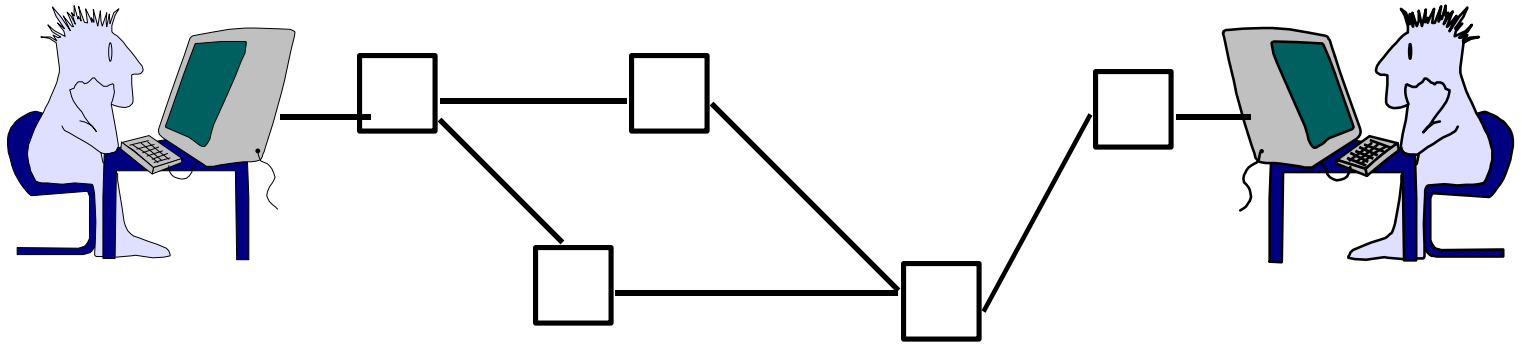
Professional Communities

- IETF:
  - Internet Engineering Task Force, www.ietf.org
  - Originated by DARPA for TCP/IP protocol development
  - Now chartered by Internet Society
  - Request for Comments (RFC),
    E.g., www.ietf.org/rfc/rfc0793.txt = TCP
  - Internet Drafts: ftp.ietf.org/internet-drafts/
    - draft-ietf-diffserv-framework-02.txt
    - draft-bhani-mpls-te-eval-00.txt

ISO/OSI Reference Model

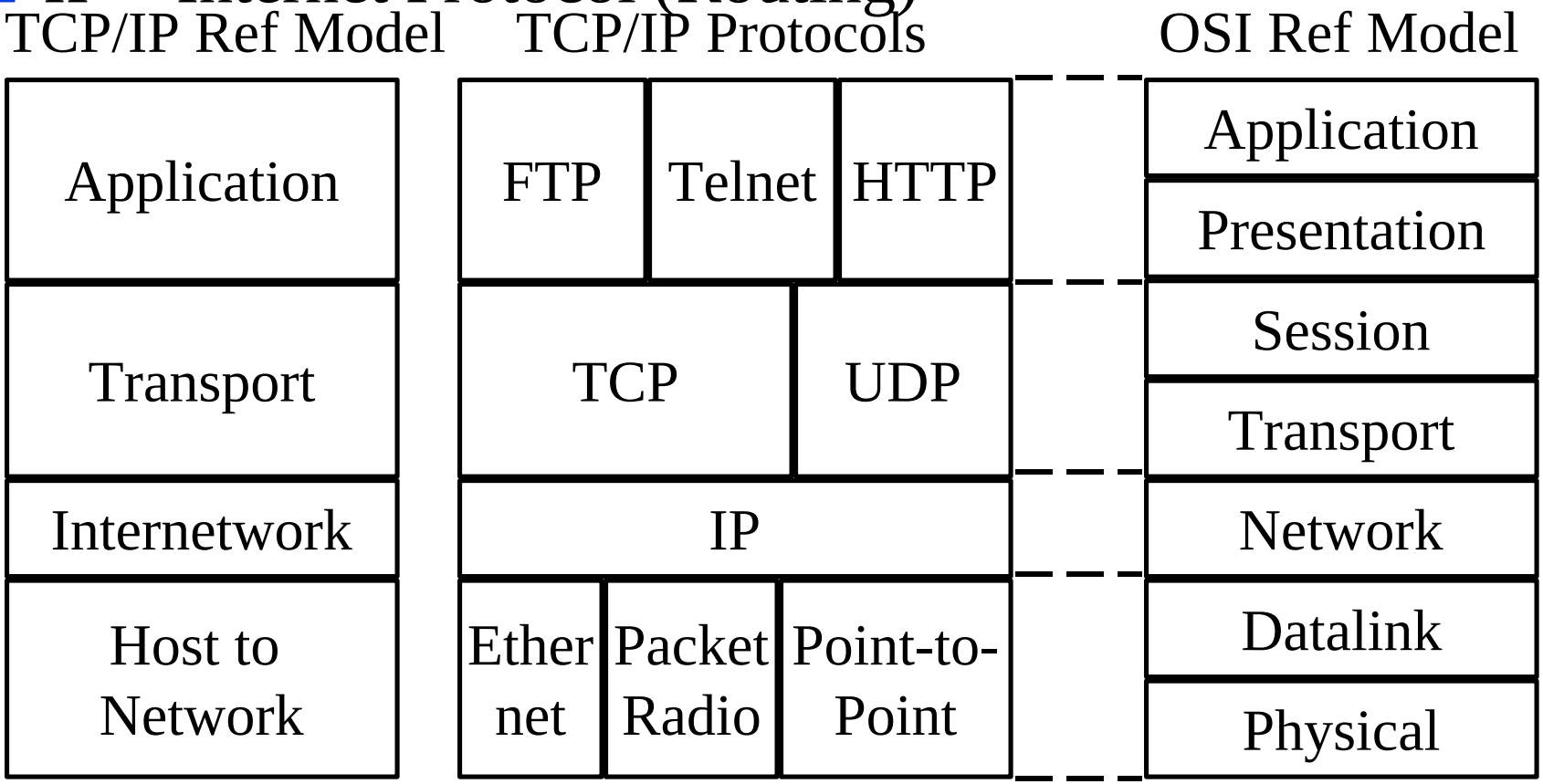


File transfer, Email, Remote Login
ASCII Text, Sound
Establish/manage connection
End-to-end communication: TCP
Routing, Addressing: IP
Two party communication: Ethernet
How to transmit signal: Coding



TCP/IP Reference Model

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



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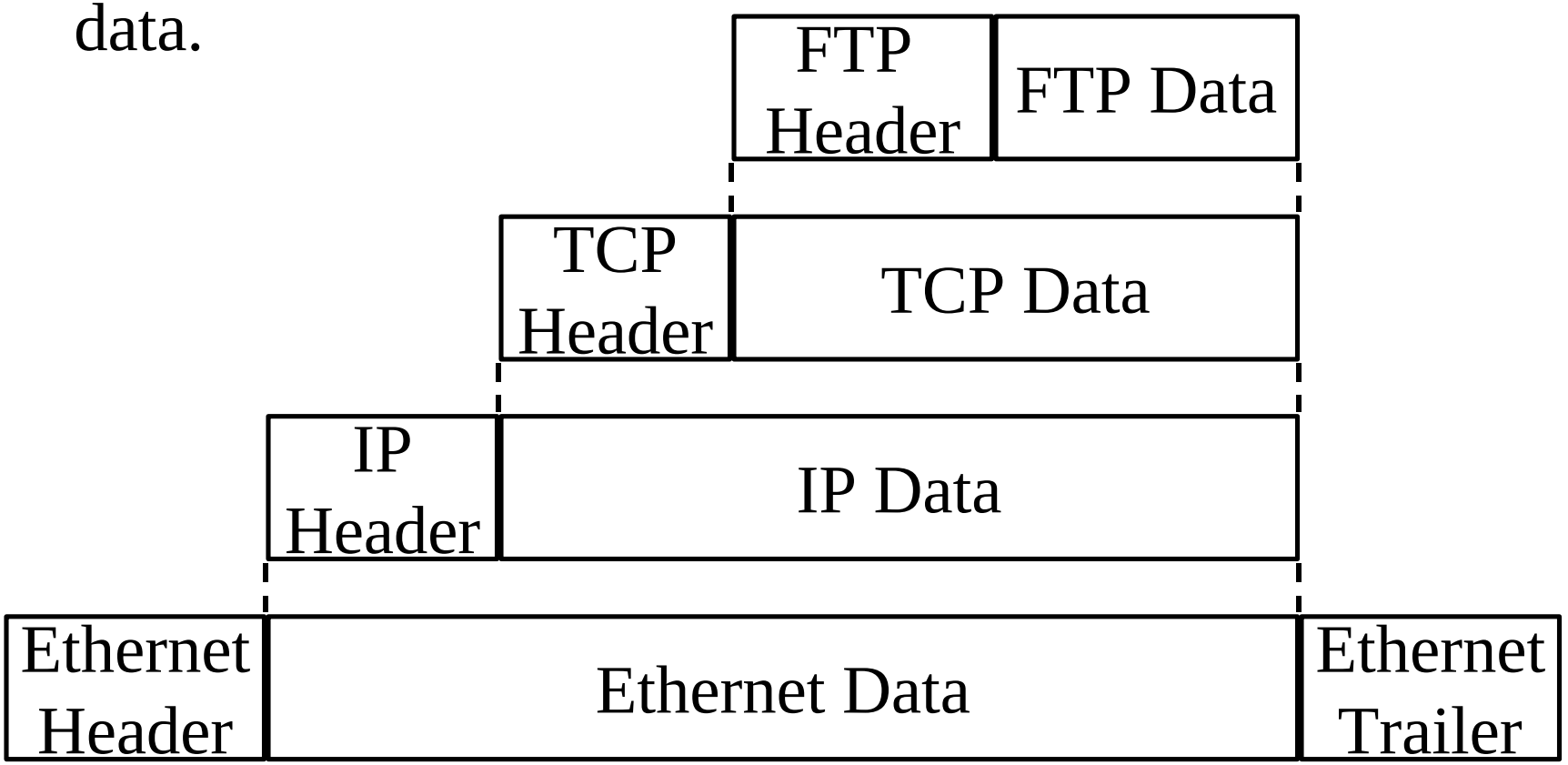
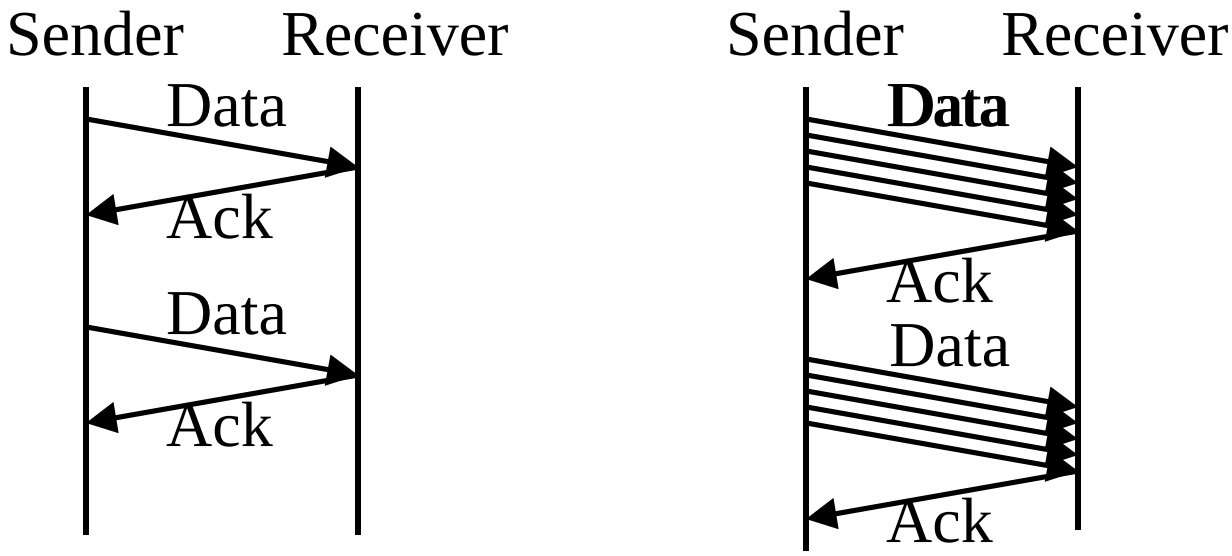
Layered Packet Format

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



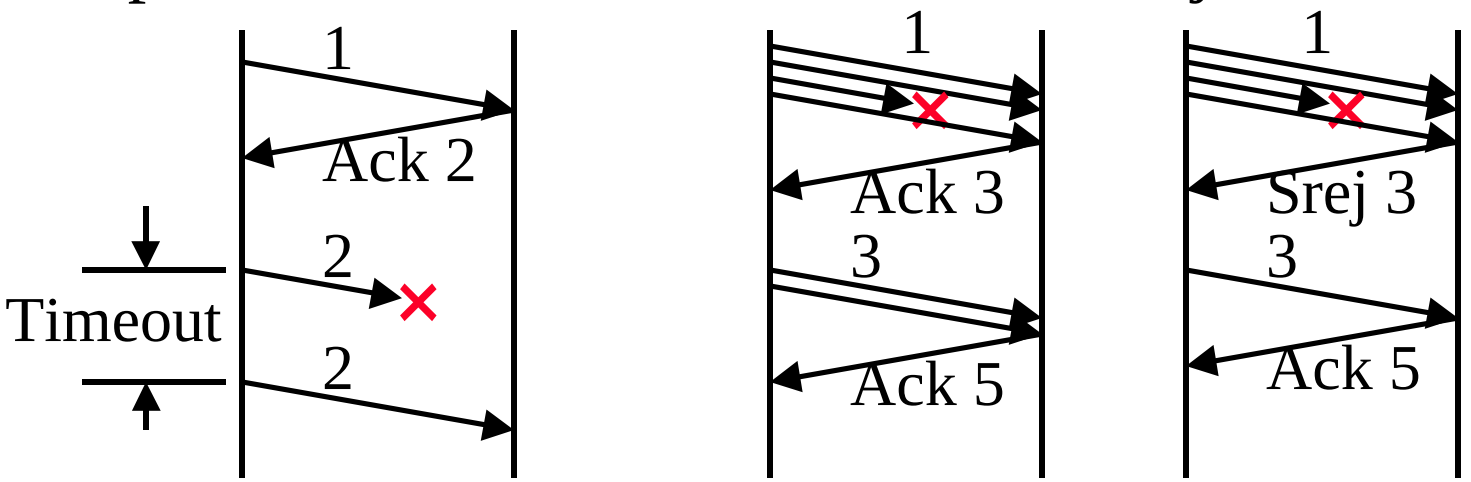
Flow Control

- 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 Detection: Cyclic Redundancy Check, Sequence Numbers, Ack/Nak, Time-out
- Error Recovery: Automatic Repeat Request (ARQ) Stop and Wait, Go back n Selective Reject



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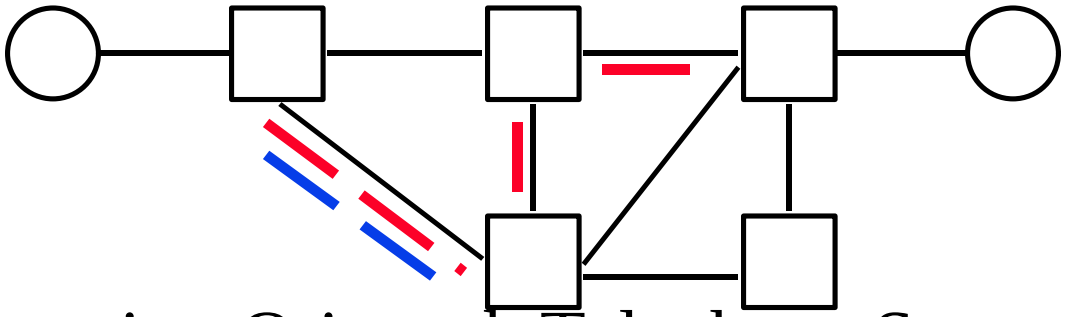
Connection-Oriented vs Connectionless



- 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.

Ethernet Standards

- 10BASE5: 10 Mb/s over coaxial cable (ThickWire)
- 10BROAD36: 10 Mb/s over broadband cable, 3600 m max segments
- 1BASE5: 1 Mb/s over 2 pairs of UTP
- 10BASE2: 10 Mb/s over thin RG58 coaxial cable (ThinWire), 185 m max segments
- 10BASE-T: 10 Mb/s over 2 pairs of UTP
- 10BASE-FL: 10 Mb/s fiber optic point-to-point link
- 10BASE-FB: 10 Mb/s fiber optic backbone (between repeaters). Also, known as synchronous Ethernet.

HDLC Family

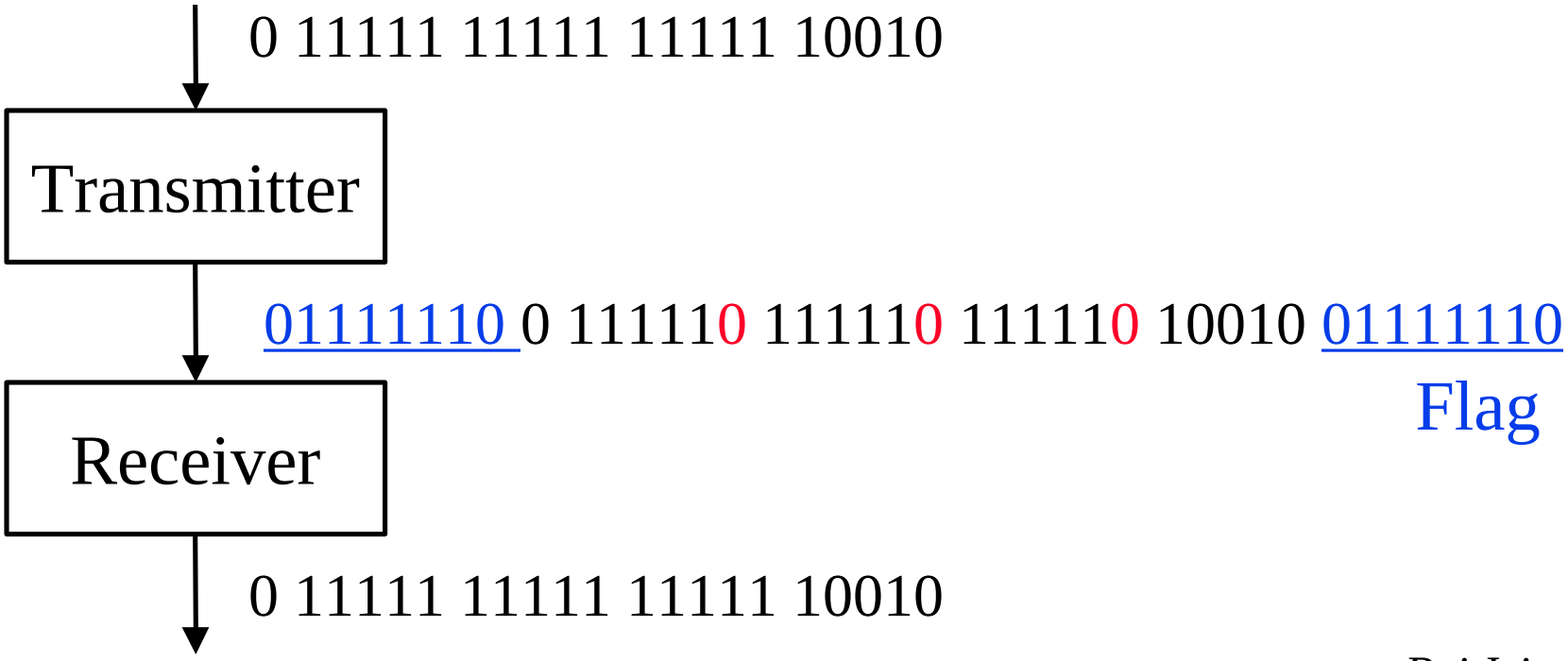
- Synchronous Data Link Control (SDLC): IBM
- High-Level Data Link Control (HDLC): ISO
- Link Access Procedure-Balanced (LAPB): X.25
- Link Access Procedure for the D channel (LAPD): ISDN
- Link Access Procedure for modems (LAPM): V.42
- Link Access Procedure for half-duplex links (LAPX): Teletex
- Point-to-Point Protocol (PPP): Internet
- Logical Link Control (LLC): IEEE
- Advanced Data Comm Control Proc (ADCCP): ANSI
- V.120 and Frame relay also use HDLC

HDLC

- Primary station: Issue commands
- Secondary Station:Issue responses
- Combined Station: Both primary and secondary
- Unbalanced Configuration: One or more secondary
- Balanced Configuration: Two combined station
- Normal Response Mode (NRM): Response from secondary
- Asynchronous Balanced Mode (ABM): Combined Station
- Asynchronous Response Mode (ARM): Secondary may respond before command

HDLC Framing: Bit Stuffing

- HDLC frames are delimited by flags: 01111110
- Stuff bits if pattern appears in data
- Remove stuffed bits at destination



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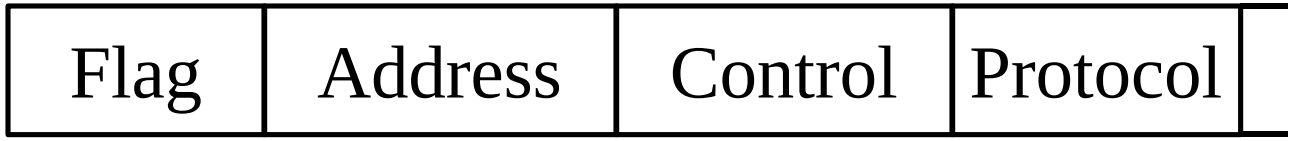
HDLC Frames

- Information Frames: User data
  - Piggybacked Acks: Next frame expected
  - Poll/Final = Command/Response
- Supervisory Frames: Flow and error control
  - Go back N and Selective Reject
  - Final ⇒No more data to send
- Unnumbered Frames: Control
  - Mode setting commands and responses
  - Information transfer commands and responses
  - Recovery commands and responses
  - Miscellaneous commands and responses

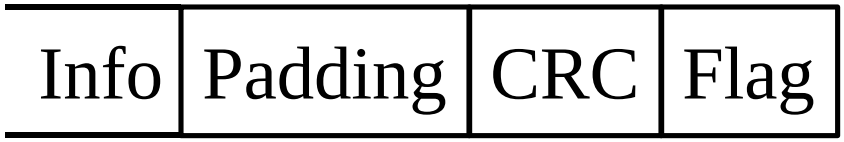
PPP: Introduction

- Point-to-point Protocol
- Originally for User-network connection
- Now being used for router-router connection also
- PPP is used when you connect to an internet service provider (ISP) via modem
- PPP is a variation of HDLC
- Uses flags like HDLC
- Uses byte stuffing in stead of bit stuffing

PPP in HDLC-Like Framing



01111110 11111111 00000011



- Flag = 0111 1110 = 7E
- Byte Stuffing:

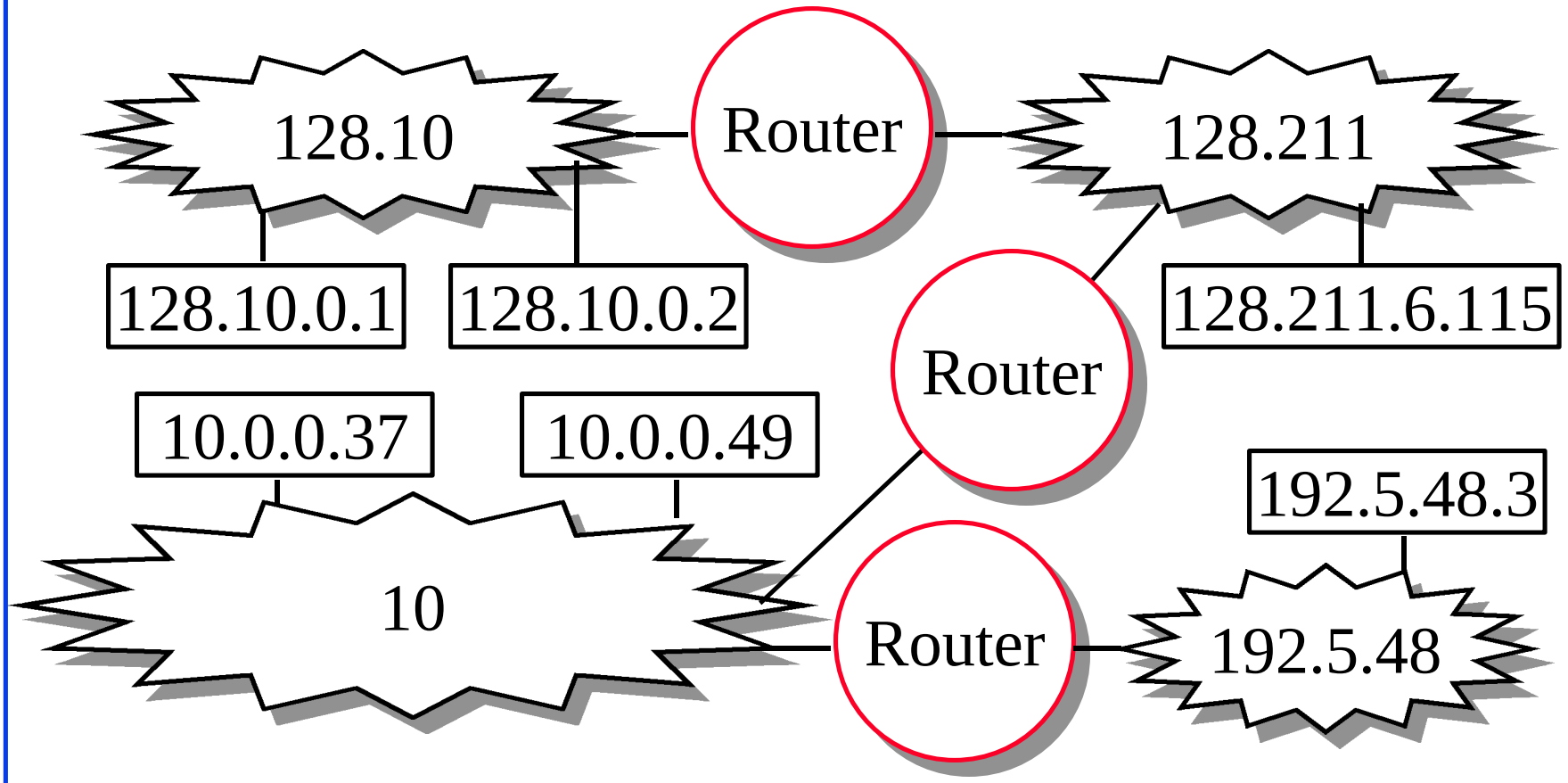
  7E ⇒ 7D 5E

  7D ⇒ 7D 5D

Internet Protocol (IP)

- Connectionless service. Variable size datagrams
- Best-effort delivery: Delay, out-of-order, corruption, and loss possible. Higher layers should handle these.
- Handles only data forwarding
  Uses routing tables prepared by other protocols, e.g.,
  Open Shortest Path First (OSPF),
  Routing Information Protocol (RIP)
- Provides only "Send" and "Delivery" services
  Error and control messages generated by
  Internet Control Message Protocol (ICMP)
- IP address: 32-bit = 4 decimal #s, e.g., 164.107.61.210

IP Addressing: An Example



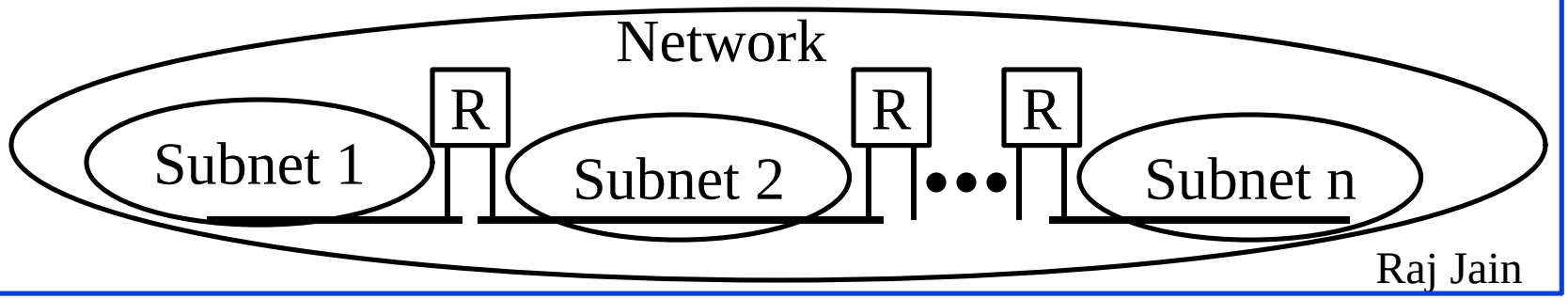
- All hosts on a network have the same network prefix

Fig 14.6

Subnetwork

- Network = Multiple subnets connected via routers
- Generally each subnet is one Ethernet
- All hosts on the subnet have the same address prefix
- Mask .AND. Address = Prefix
- Example: First 23 bits = subnet

  Address: 10010100 10101000 00010000 11110001
  Mask: 11111111 11111111 11111110 00000000
  .AND. 10010100 10101000 00010000 00000000



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Forwarding an IP Datagram

- Delivers datagrams to destination network (subnet)
- Routers maintain a "routing table" of "next hops"
- Next Hop field does not appear in the datagram

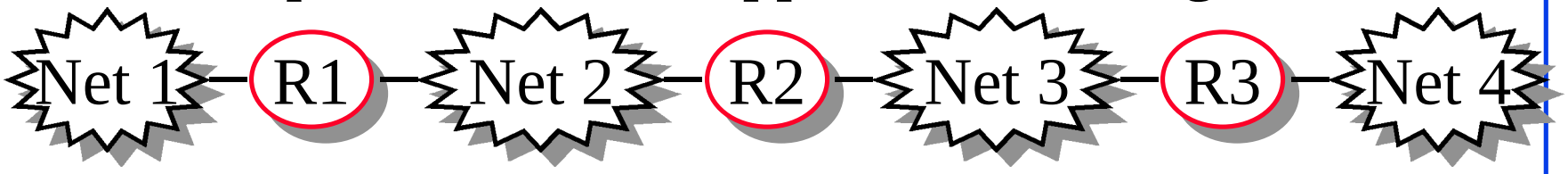


Table at R2:

Destination	Next Hop
Net 1	Forward to R1
Net 2	Deliver Direct
Net 3	Deliver Direct
Net 4	Forward to R3

Fig 16.2

IPv6: How Many Addresses?

- 10 Billion people by 2020
- Each person will be served by more than one computer
- Assuming 100 computers per person $\Rightarrow 10^{12}$ computers
- More addresses may be required since
  - Multiple interfaces per node
  - Multiple addresses per interface
- Some believe 2^6 to 2^8 addresses per host
- Safety margin $\Rightarrow 10^{15}$ addresses
- IPng Requirements $\Rightarrow 10^{12}$ end systems and 10^9 networks. Desirable 10^{12} to 10^{15} networks

IPv6 Addresses

- 128-bit long. Fixed size
- $2^{128} = 3.4\times10^{38}$ addresses
  $\Rightarrow 665\times10^{21}$ addresses per sq. m of earth surface
- If assigned at the rate of $10^6/\mu s$, it would take 20 years
- Expected to support 8×10^{17} to 2×10^{33} addresses
  $8\times10^{17} \Rightarrow$ 1,564 address per sq. m
- Allows multiple interfaces per host.
- Allows multiple addresses per interface
- Allows unicast, multicast, anycast
- Allows provider based, site-local, link-local
- 85% of the space is unassigned

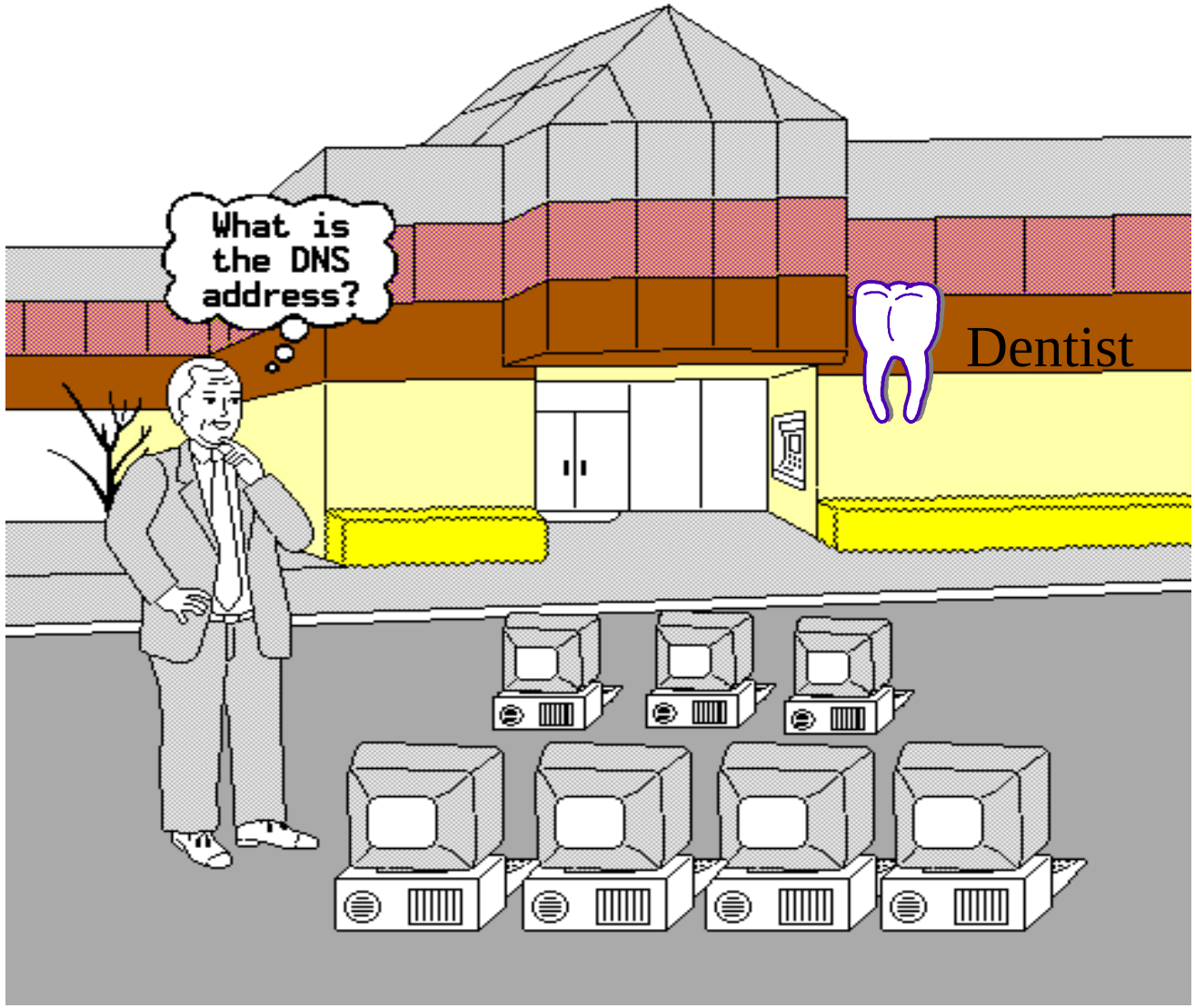
Colon-Hex Notation

- **Dot-Decimal**: 127.23.45.88
- **Colon-Hex:**
  FEDC:0000:0000:0000:3243:0000:0000:ABCD
  - Can skip leading zeros of each word
  - Can skip one sequence of zero words, e.g.,
    FEDC::3243:0000:0000:ABCD
    ::3243:0000:0000:ABCD
  - Can leave the last 32 bits in dot-decimal, e.g.,
    ::127.23.45.88
  - Can specify a prefix by /length, e.g.,
    2345:BA23:7::/40

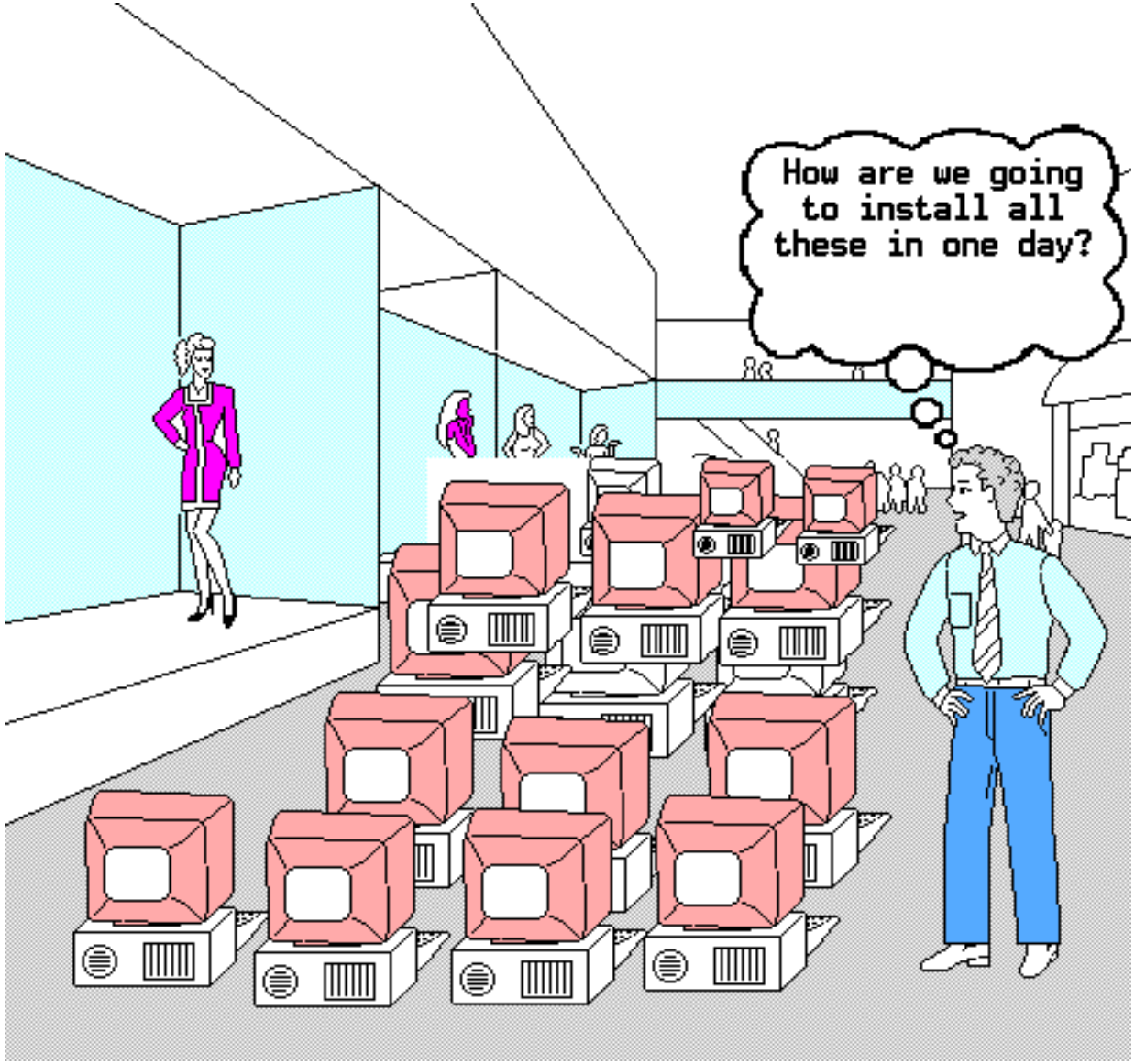
IPv6 vs IPv4

- 1995 vs 1975
- IPv6 only twice the size of IPv4 header
- Only version number has the same position and meaning as in IPv4
- Added: Priority and flow label
- All fixed size fields.
- No optional fields. Replaced by extension headers.
- Allows “Plug and Play” as well as “Secure” address assignment

Dentist's Office



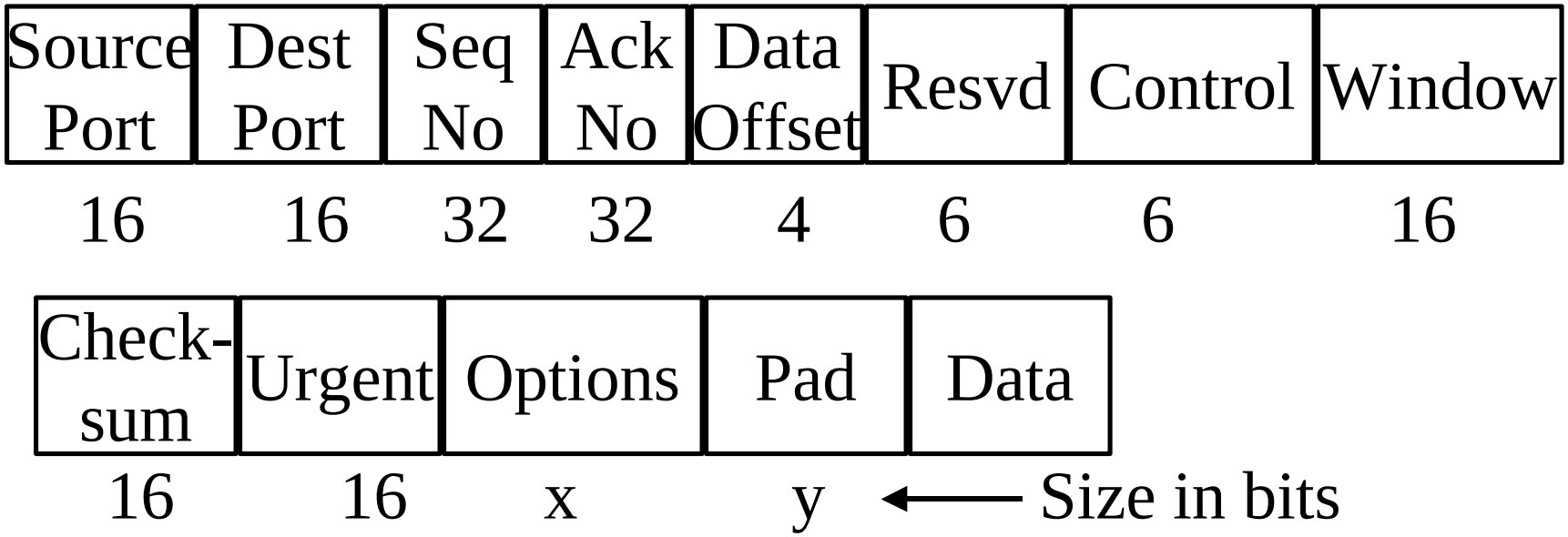
1000 Computers on the Dock



TCP: Key Features

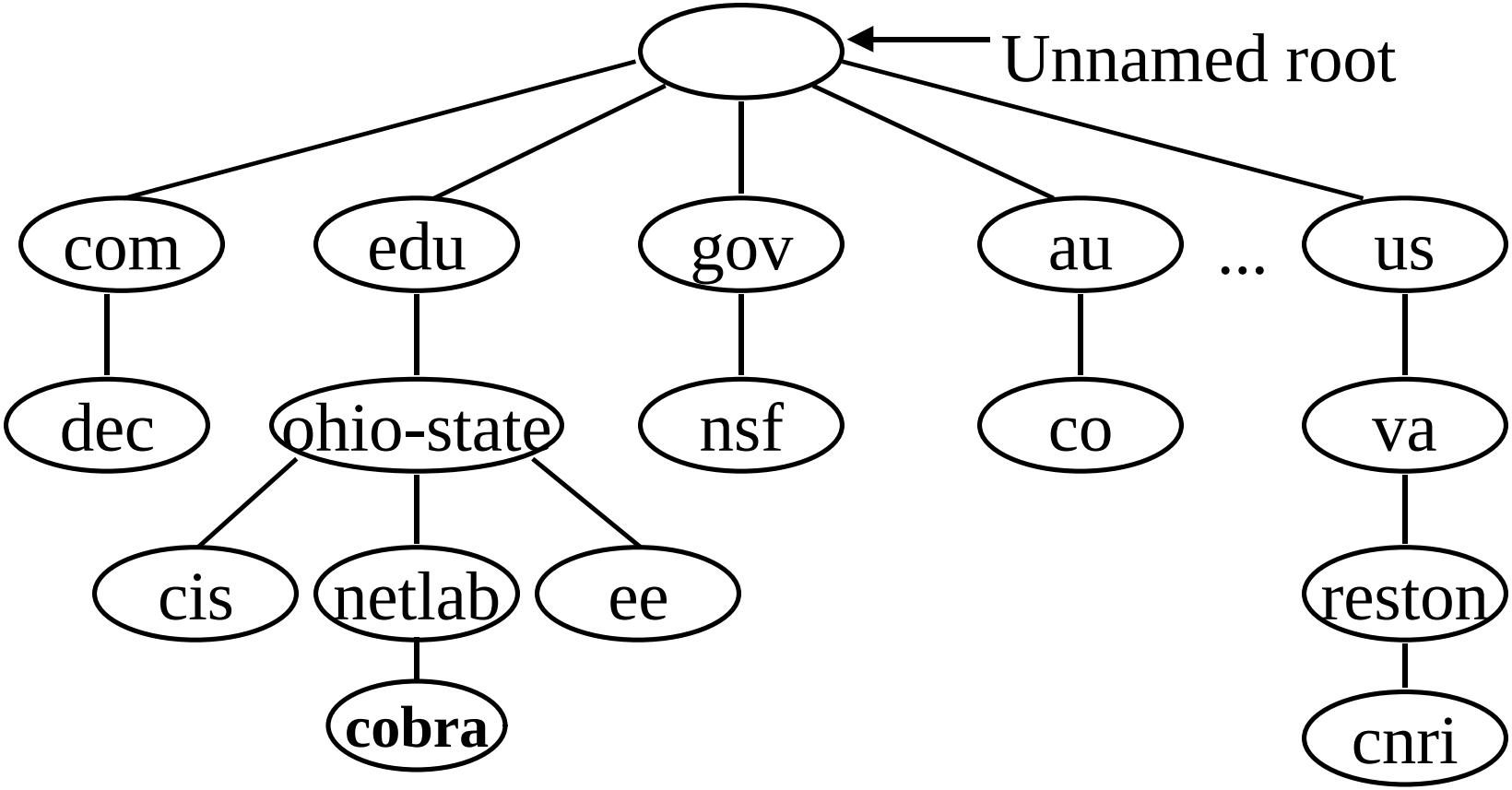
- Connection oriented
- Point-to-point communication: Two end-points
- Reliable transfer: Data is delivered in order
- Full duplex communication
- Stream interface: Continuous sequence of octets
- Reliable connection startup: Data on old connection does not confuse new connections
- Graceful connection shutdown: Data sent before closing a connection is not lost.

TCP Header



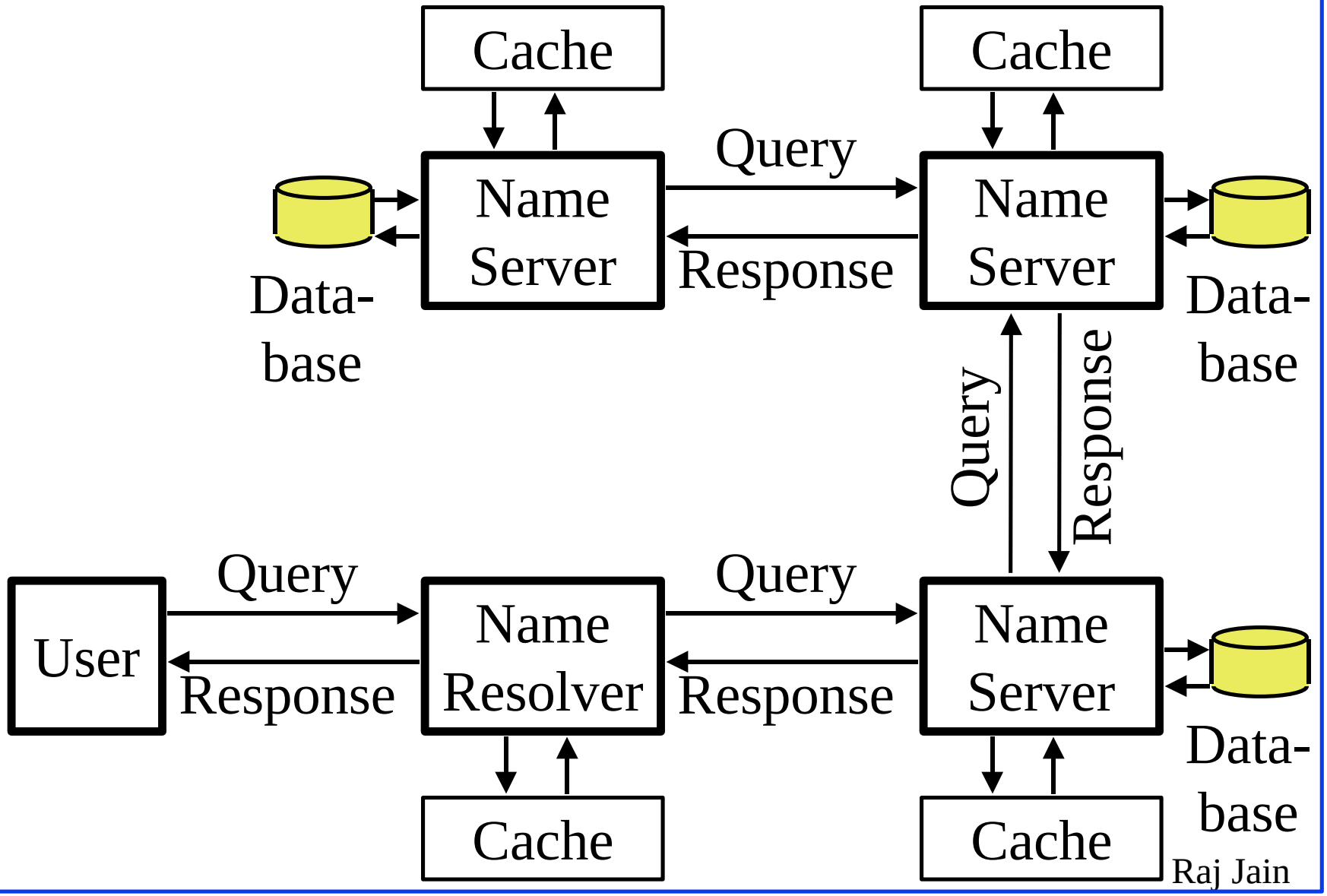
- Port (16 bits): Identifies source user process
  20 = FTP, 23 = Telnet, 53 = DNS, 80 = HTTP, ...
- Ack number (32 bits): Next byte expected
- Window = Number bytes allowed to send

Domain Name System: Hierarchy

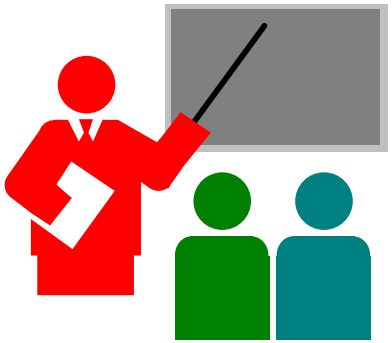


- Example: cobra.netlab.ohio-state.edu

Name Resolution



Summary



- IETF's RFCs and I-Ds are key sources for recent developments
- HDLC uses 01111110 flag and requires bit-stuffing
- Ethernet uses CSMA/CD
- IP is a connectionless forwarding protocol with 32-bit addresses
- IPv6 extends addresses to 128 bits
- TCP is a connection-oriented reliable stream protocol
- DNS allows name to address resolution

Networking Basics: Key References

- W. Stallings, "Data and Computer Communications," 5th Ed, Prentice Hall, 1997
- M. W. Murhammer, et al, "TCP/IP Tutorial and Technical Overview," 6th Ed, Prentice Hall, 1998
- A. S. Tanenbaum, "Computer Networks," 3rd Ed, Prentice Hall, 1996