Networking Applications

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Introduction

Outline

- Introduction
- Internet Layers
- Internet Data Packet transmission
- Network Protocols layers

Introduction 1/2

- What is a network? Set of nodes connected by communication links
  - Components
    - ✓(Network edge) Computing devices (end hosts, PDAs, …) connected to the network
    - ✓(Network core) Routers/switches that move data through the network
    - ✓(Media) Physical links that carry information (fiber, copper, radio, and satellite)
    - ✓Applications that communicate with each other to provide services (Email, file transfer, and Web browsing).
- What is an internetwork? A network of networks (an internet)
  - Specific example is the ***Internet***

Introduction 2/2

- Network physical topology
  - ➢ Geometric representation of the relationship of all the links and nodes to one another
  - ➢ Categories: *mesh*, *star*, *bus*, and *ring*
- Network Categories
  - Local-Area Network (LAN)
  - Metropolitan-Area Network (MAN)
  - Wide-Area Network (WAN)
  - Personal-Area Network (PAN)

The Internet 1/2

- ARPA (Advanced Research Projects Agency) in DoD wanted to find a way to connect computers that were stand-alone in mid 1960s
- In 1967, ARPA presented idea for ARPANET (an ACM meeting)
- In 1969, ARPANET was a reality (4 nodes → UCLA, UCSB, Stanford Research Institute SRI, and Univ. of Utah)
- In 1973, landmark paper (by Vint Cerf and Bob Khan) outlined protocols to achieve end-to-end delivery of packets (TCP)
- Split TCP into 2 protocols: IP to handle datagram routing, and TCP higher-level functions such as segmentation, reassembly, and error detection
- For Internet pioneers, see http://www.ibiblio.org/pioneers/

The Internet 2/2

- Not a simple hierarchical structure (For a host count, see http://www.isc.org/solutions/survey/history)
- Internet Service Providers
  - ➢ International/National/Regional service providers versus Local service providers (direct service to end-users)
- Internet Standards → RFCs (Request For Comments) by IETF (Internet Engineering Task Force)
- Internet Protocols: control sending and receiving of messages (TCP, IP, HTTP, FTP, …)
- Communication Services → Connectionless or Connection-oriented

Connection-oriented versus Connectionless 1/2

- Connection-oriented
  - ➢ Setup data transfer ahead of time (through *handshaking*)
  - ➢ Internet's connection-oriented service is TCP (Transmission Control Protocol) [RFC 793]. It provides
    - ✓ reliable, in-order byte delivery
    - ✓ flow control
    - ✓ congestion control.
  - ➢ Applications using TCP: Email (SMTP), web browsing (HTTP), and file transfer (FTP)

Connection-oriented versus Connectionless 2/2

- Connectionless
  - Internet's connectionless service is UDP (User Datagram Protocol) [RFC 768] . It provides
    - ✓unreliable data transfer
    - ✓no flow control
    - ✓no congestion control
  - Applications using UDP: streaming media, video conferencing, and IP telephony

Network Protocols

- Applications to communicate across a computer network
  - ➢ Invent a *protocol* (an agreement how will communicate)
  - ➢ Which application is expected to initiate communicate and when responses are expected
    - ✓ Syntax: format of data
    - ✓ Semantics: meaning of each section of bits (How it is interpreted and what action (s) to be taken)
    - ✓ Timing: when data should be sent and how fast?
- Example: Web Server and Web client
- Other examples? Other modes of communication?

Protocol "Layers" 1/2

•Used in daily life! → 2 friends communicating through the mail (sender, receiver, and a carrier)

•Sender side

- ➢Layer 1: Write letter, insert letter in envelope, write sender and receiver address, drop letter in mailbox
- ➢Layer 2: letter picked up by carrier and delivered to post office
- ➢Layer 3: letter stored at post office, a carrier transports the letter

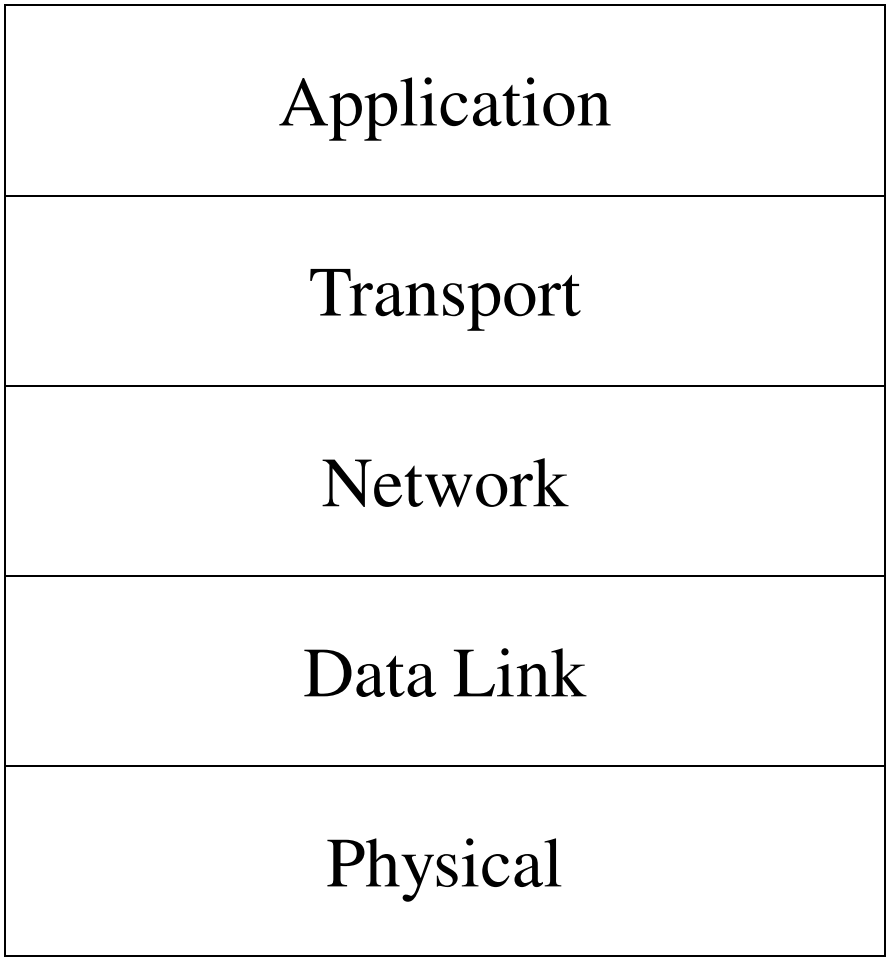
•On the way → Letter on the way to recipient's local post office (maybe through a central office), transported by truck, train, airplane, boat, or a mix

•Receiver Side → Layer3, then Layer 2, then Layer 1

Protocol "Layers" 2/2

- Characteristics
  - Each layer implements a service
  - Via its own internal-layer actions (a layer is a *black-box*)
  - Relying on services provided by layer below
- Why layering?
  - explicit structure allows identification, relationship of complex system's pieces (modular approach)
    - ✓ layered reference model for discussion
  - modularization eases maintenance, updating of system
    - ✓ change of implementation of layer's service transparent to rest of system
  - layering considered harmful?
    - ✓ Different layers may duplicate functionality
    - ✓ Different layers may need access to same information

Internet Layers



Supporting network applications (HTTP, FTP, DNS, …)

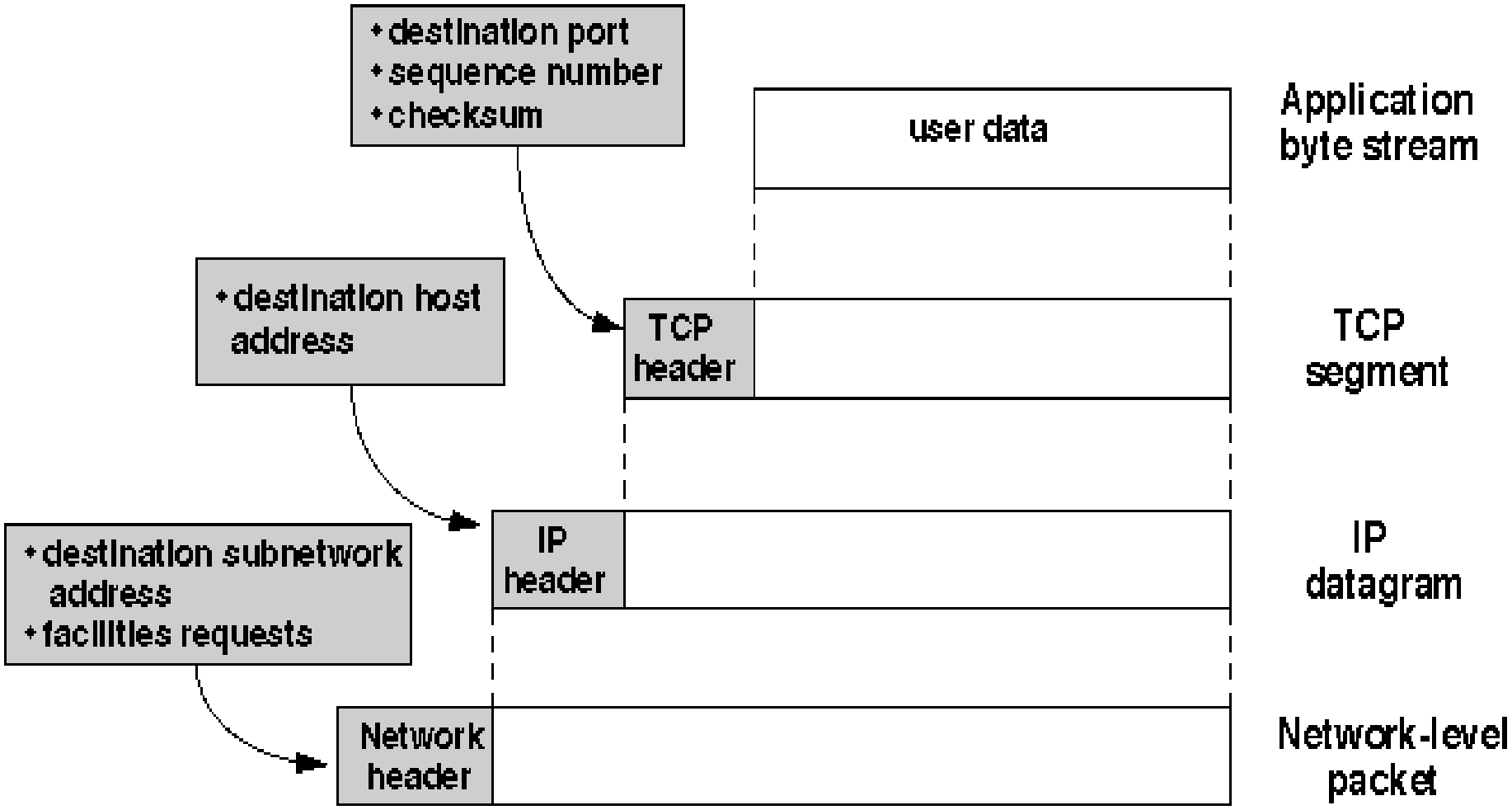
Transporting application-layer ***messages*** between client and server sides of an application (TCP and UDP)

Routing ***datagrams*** from one host to another (IP protocol: IPv4 and IPv6)

Move entire ***frames*** from one network element to an adjacent network element (Ethernet, PPP, …)

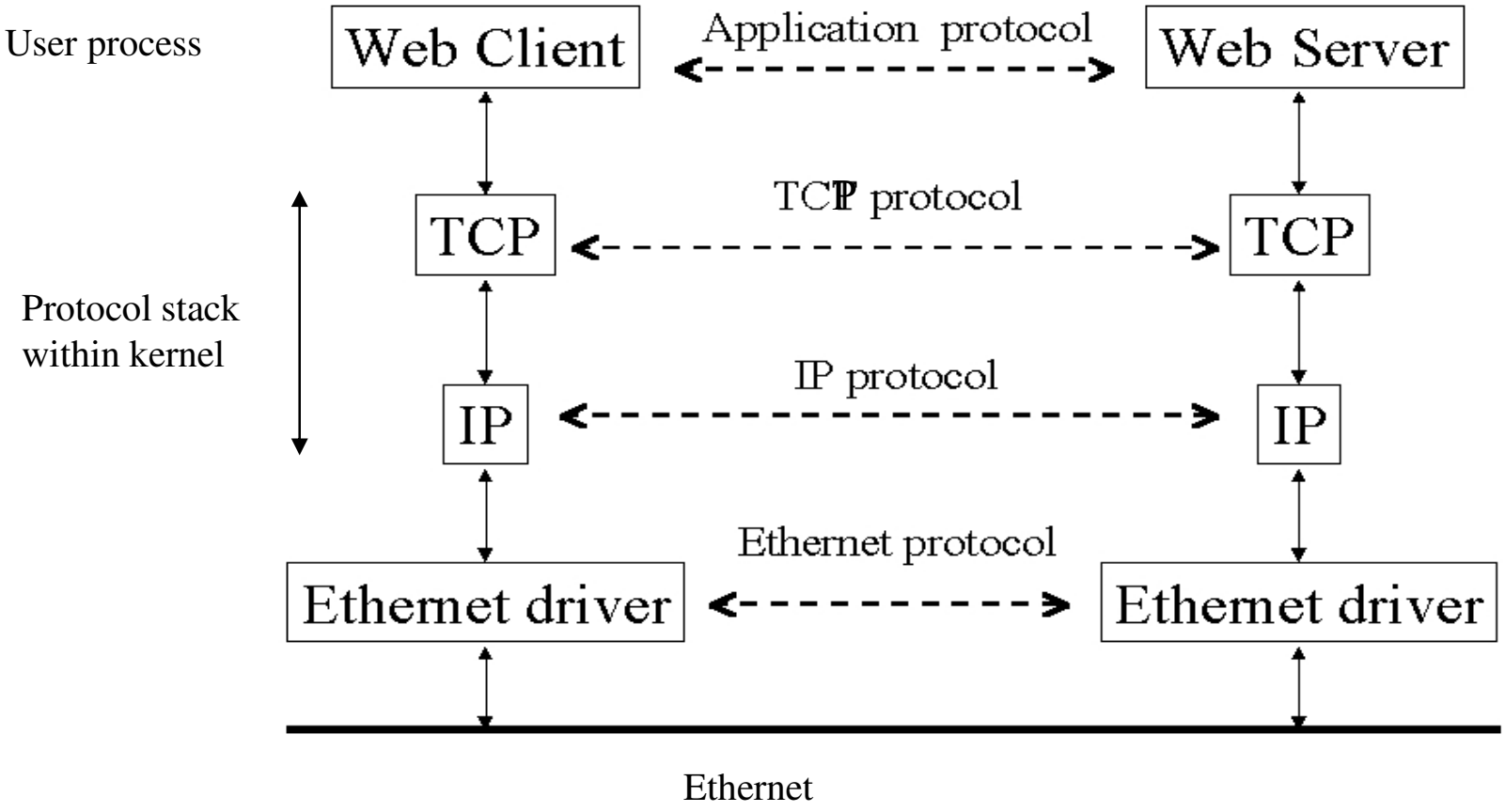
Move individual ***bits*** within the frame from one network element to an adjacent network element (coaxial cable, fiber optic, …)

TCP/IP Data Packet Transmission and Addressing



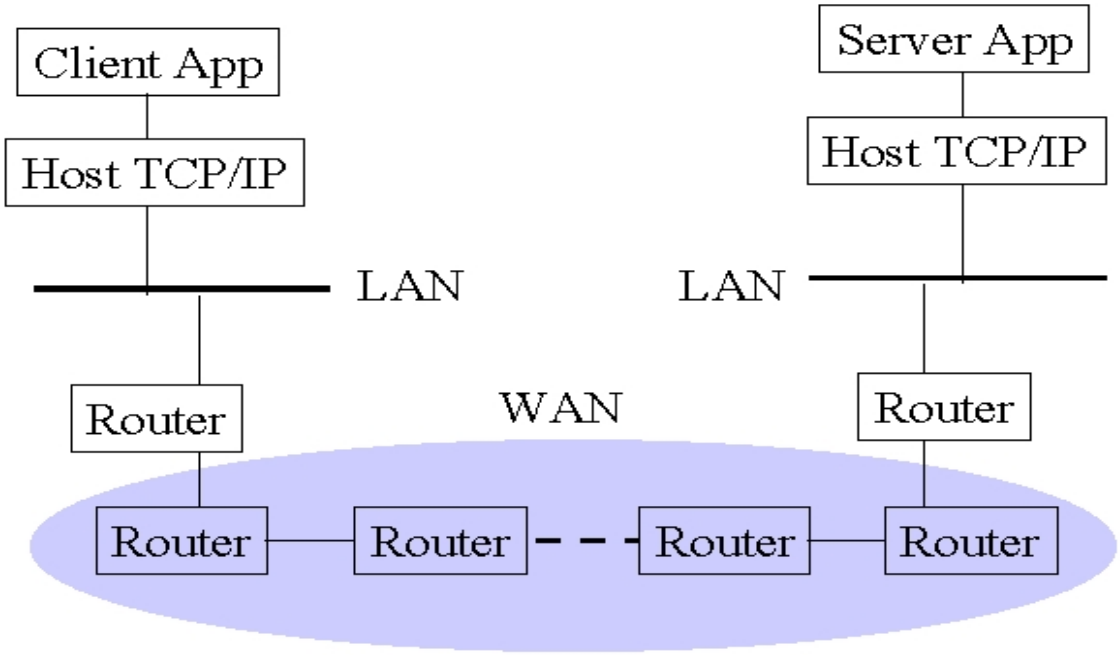
Multiple Layers of Network Protocols

Client and Server on same Ethernet



Multiple Layers of Network Protocols

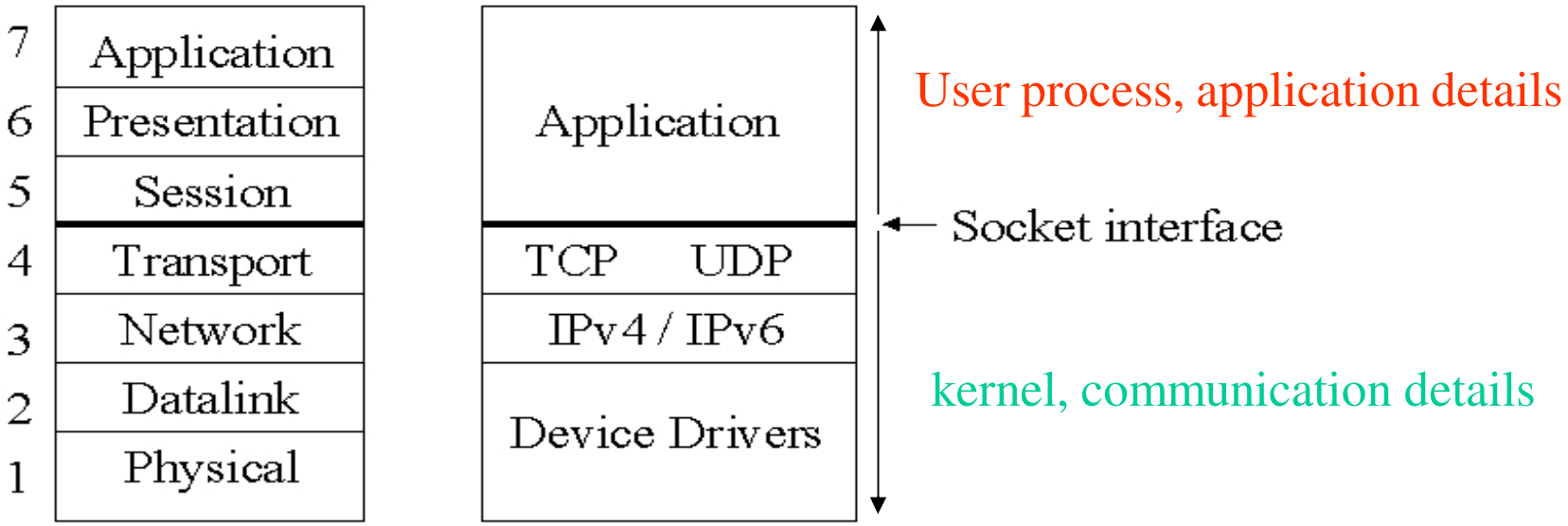
Client and server on different LANs connected through a WAN



Layers in OSI Model and Internet Protocol Suite

OSI: Open Systems Interconnection model for computer communications

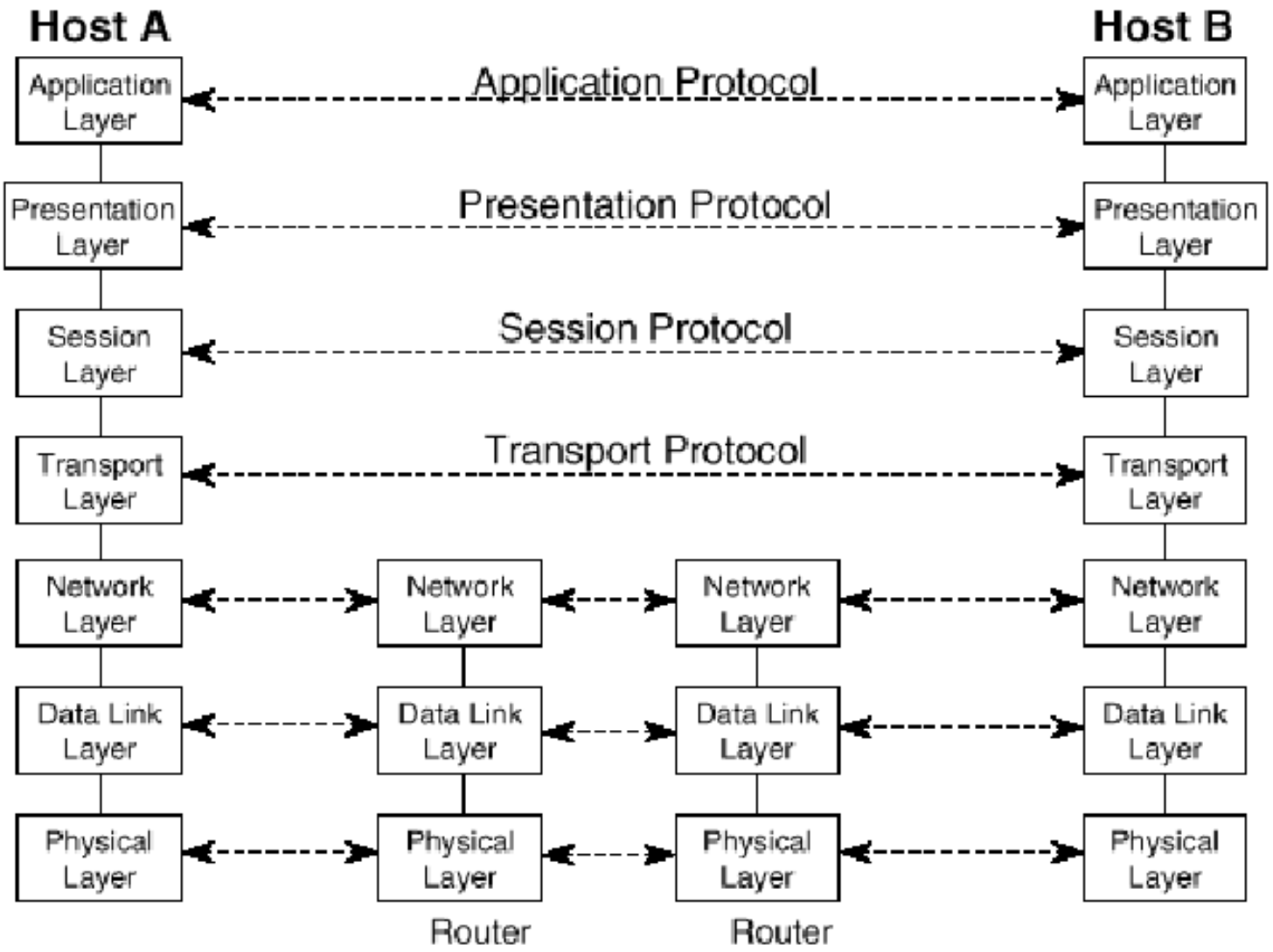
ISO: International Organization for Standardization



Outline

- OSI Layering Architecture
- TCP/IP Layers

OSI Layers



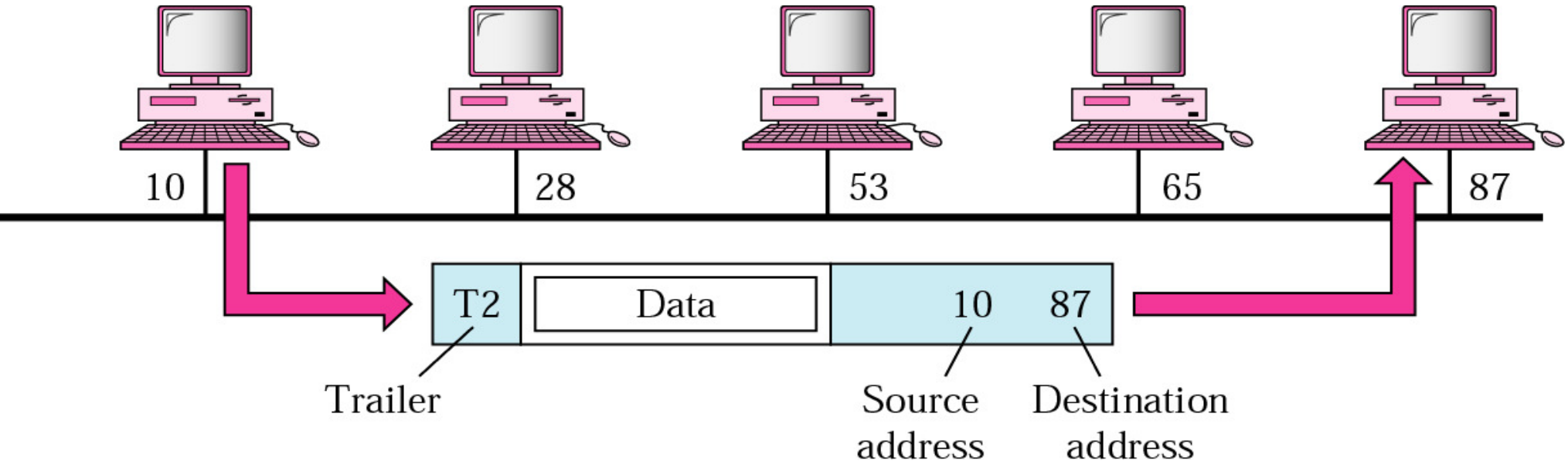
Physical Layer 1/2

- Functions
  - Transmission of a raw bit stream
  - Forms the physical interface between devices
- Issues
  - Which modulation technique (bits to pulse (analog signal))?
  - Which Line Coding technique (bits to digital signal?)
  - How long will a bit last? (*bit interval vs bit rate*)
  - Bit- serial or parallel transmission?
  - Half- or Full- duplex transmission?
  - How many pins does the network connector have?
  - How is a connection set up or torn down?

Data Link Layer 1/2

- Functions
  - Provides *reliable transfer* of information between two adjacent nodes (*physical link is a raw transmission facility*)
  - Creates frames (manageable data units) from bits and vice versa
  - Physical addressing (identify frame sender and/or receiver)
  - Provides frame- level error control (normally through a trailer added at end of frame)
  - Provides flow control
  - Access Control (through a MAC sub layer)
- In summary, the data link layer provides the network layer with what appears to be an error- free link for packets

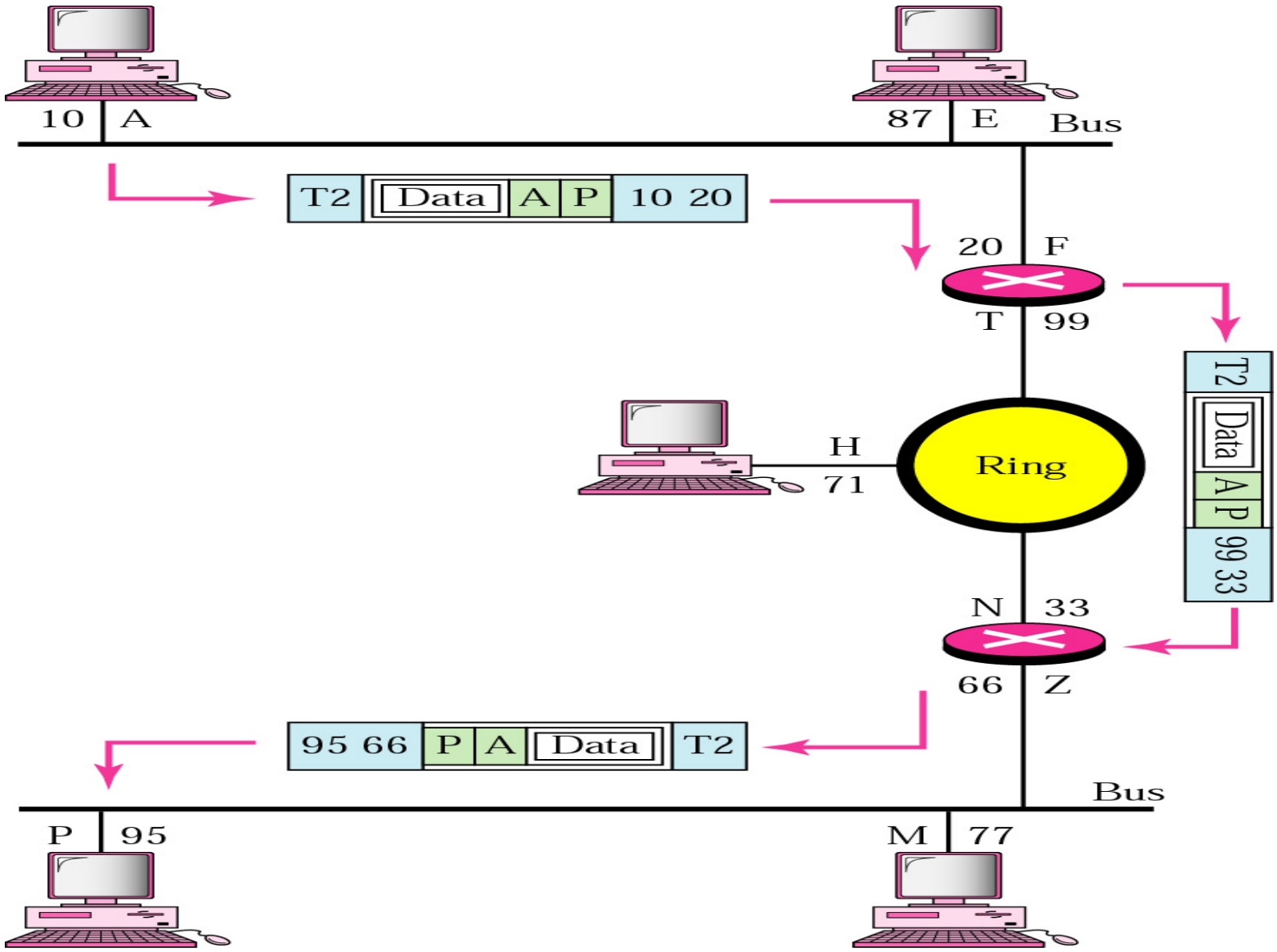
Data Link Layer 2/2



Network Layer 1/2

- Functions
  - Source-to-destination delivery of packets across multiple networks
  - Logical addressing
  - Responsible for routing decisions
    - ✓Dynamic routing
    - ✓Fixed routing
  - Performs congestion control
    - ✓In the Internet model, the network layer does not perform congestion control
    - ✓Congestion control at the network layer is a current area of research

Network Layer 2/2



Transport Layer

- Functions
  - Process-to-process delivery of entire message
  - Port addressing
  - Connection control
  - Provides reliable end-to-end communication
  - Perform end-to-end flow control
  - Perform packet retransmission when packets are lost by the network
  - In the Internet model, the transport layer also offers congestion control.

Session Layer

- Functions
  - Network dialog controller
    - ✓Establish, maintain, and synchronize interaction between communicating entities
  - May perform synchronization between several communicating applications
  - Groups several user- level connections into a single "session"

Presentation Layer

- Functions
  - ➢ Concerned with syntax and semantics of information exchanged between 2 systems
  - ➢ Performs specific functions that are requested regularly by applications
    - ✓ Encryption
    - ✓ Compression
    - ✓ Translation
      - ❑ ASCII to Unicode, Unicode to ASCII
      - ❑ LSB- first representations to MSB- first representations

Application Layer

- Functions
  - Application layer protocols are application-dependent
  - Implements communication between two applications of the same type
  - Examples
    - ✓FTP
    - ✓HTTP
    - ✓SMTP (email)

OSI Layering Problems

- Seven layers not widely accepted
- Standardized before implemented
- Top three layers fuzzy
- Internet or TCP/ IP layering widespread

Internet Design Principles

- Scale
  - Protocols should work in networks of all sizes and distances
- Incremental deployment
  - New protocols need to be deployed gradually
- Heterogeneity
  - Different technologies, autonomous organizations
- End-to-end argument
  - Networking functions should be delegated to the edges; application knows best
  - *"A function can only be completely and correctly implemented with the knowledge and help of the applications standing at the communication end points"*