

Introduction to Networks

Dr. Ayman A. Abdel-Hamid

College of Computing and Information Technology

Arab Academy for Science & Technology and
Maritime Transport

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/ops/ds/host-count-history.php>)
- 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

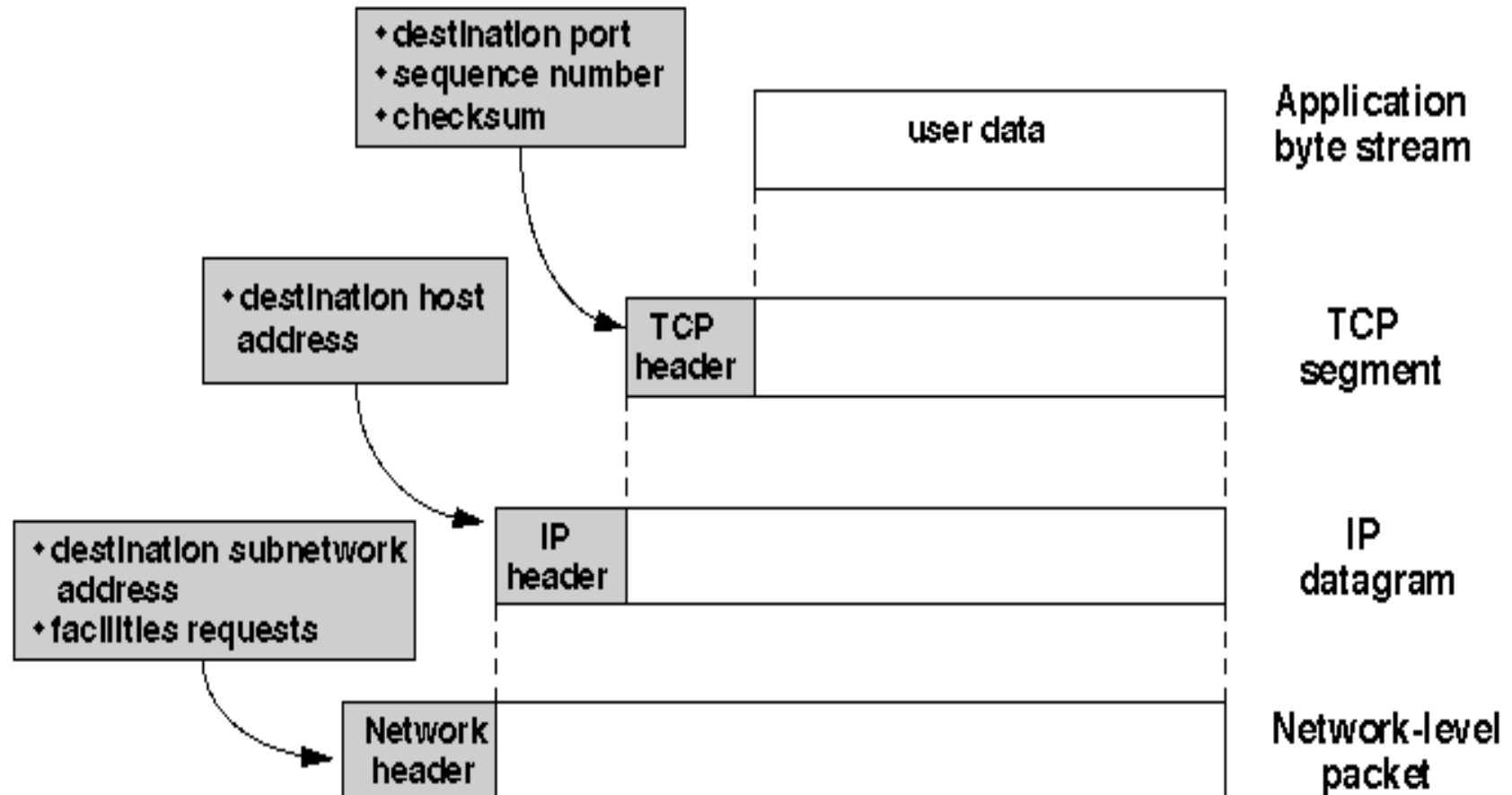
•Why layering?

- 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

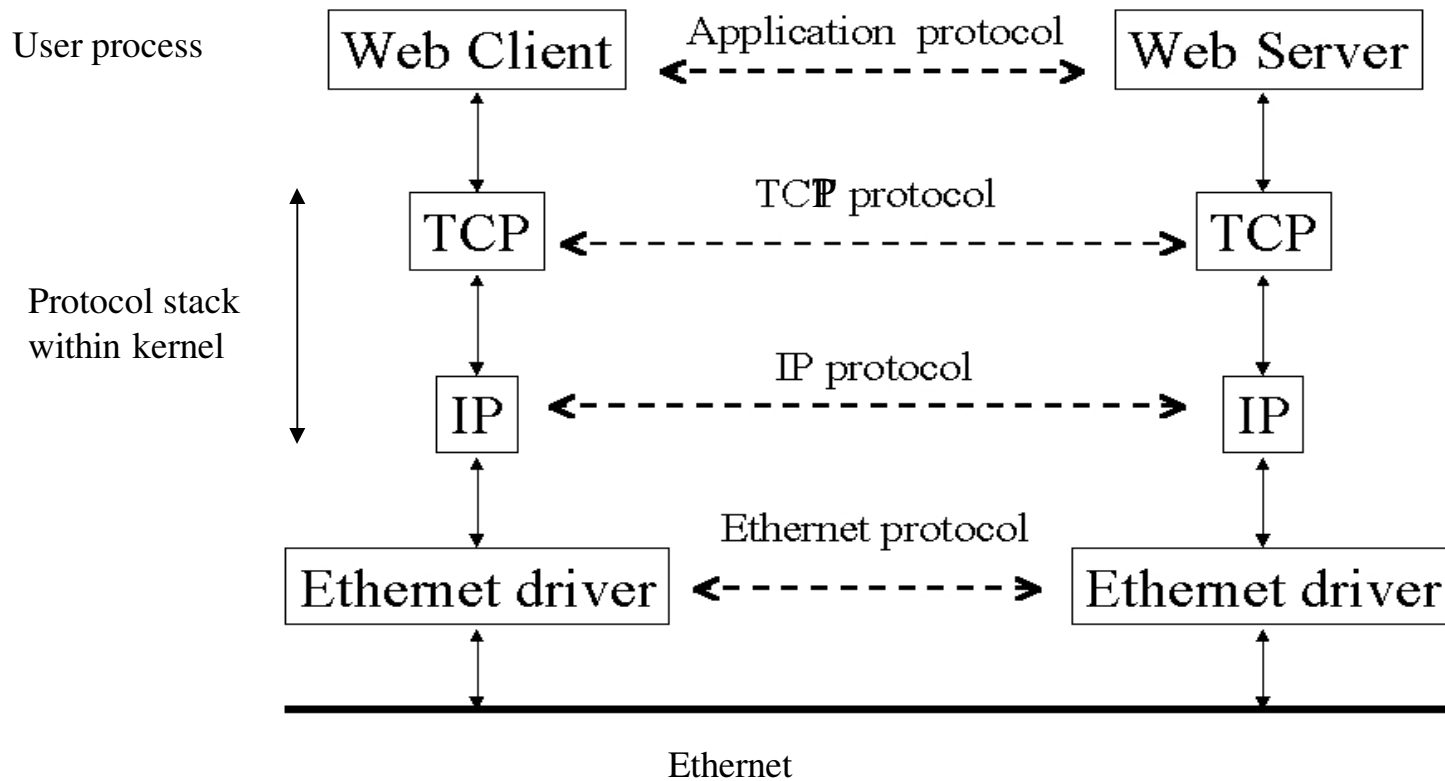
Application	Supporting network applications (HTTP, FTP, DNS, ...)
Transport	Transporting application-layer <i>messages</i> between client and server sides of an application (TCP and UDP)
Network	Routing <i>datagrams</i> from one host to another (IP protocol: IPv4 and IPv6)
Data Link	Move entire <i>frames</i> from one network element to an adjacent network element (Ethernet, PPP, ...)
Physical	Move individual <i>bits</i> within the frame from one network element to an adjacent network element (coaxial cable, fiber optic, ...)

TCP/IP Data Packet Transmission and Addressing



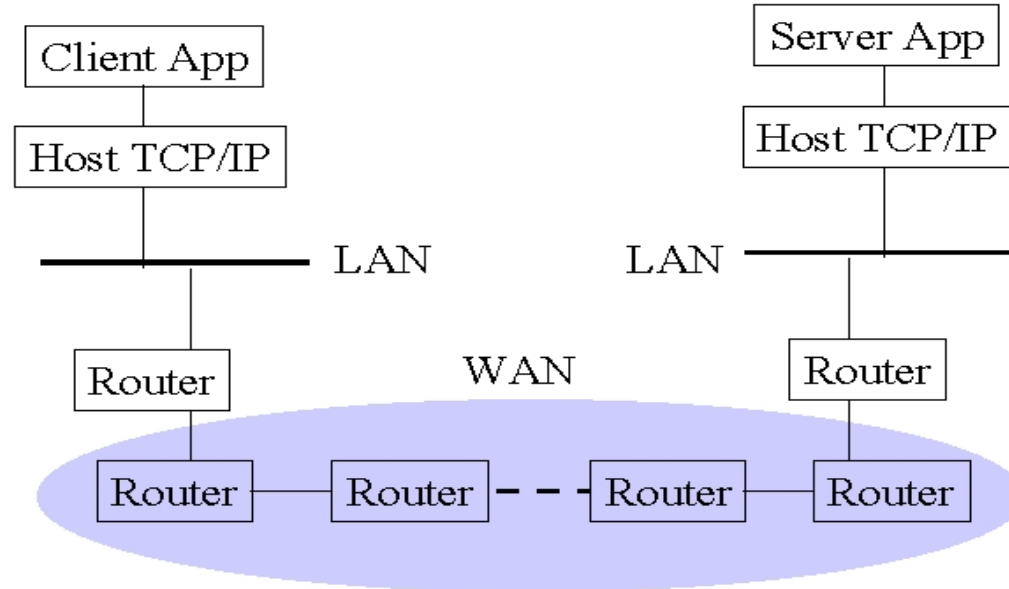
Multiple Layers of Network Protocols

Client and Server on same Ethernet



Multiple Layers of Network Protocols

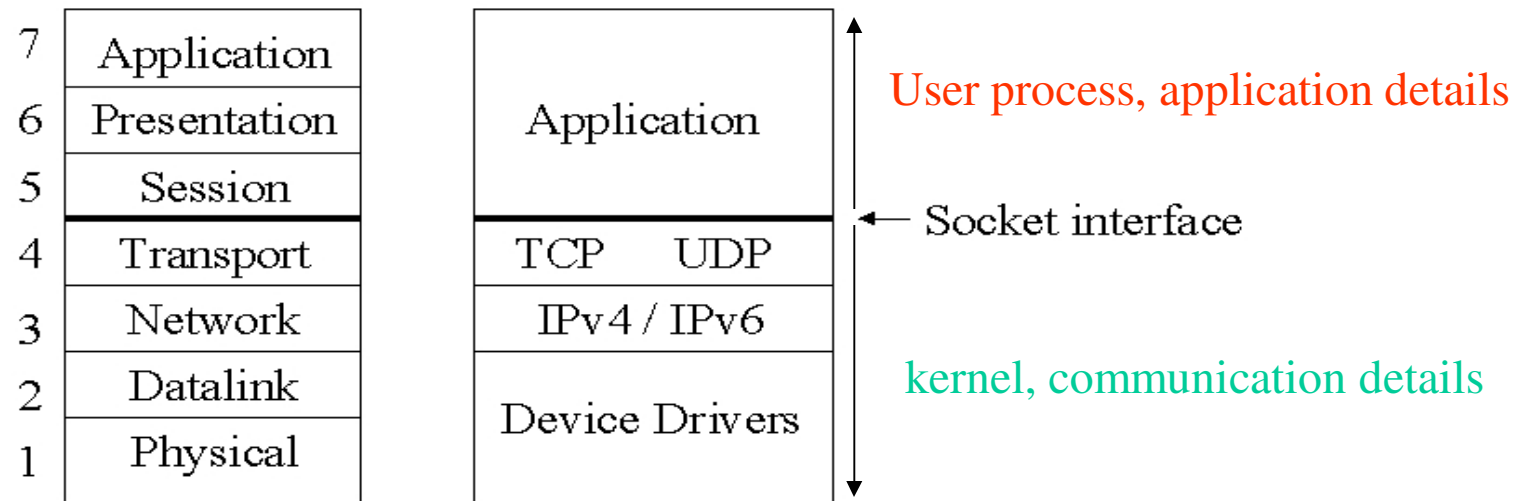
Client and server on different LANs connected through a WAN



Layers in OSI Model and Internet Protocol Suite

OSI: Open Systems Interconnection model for computer communications

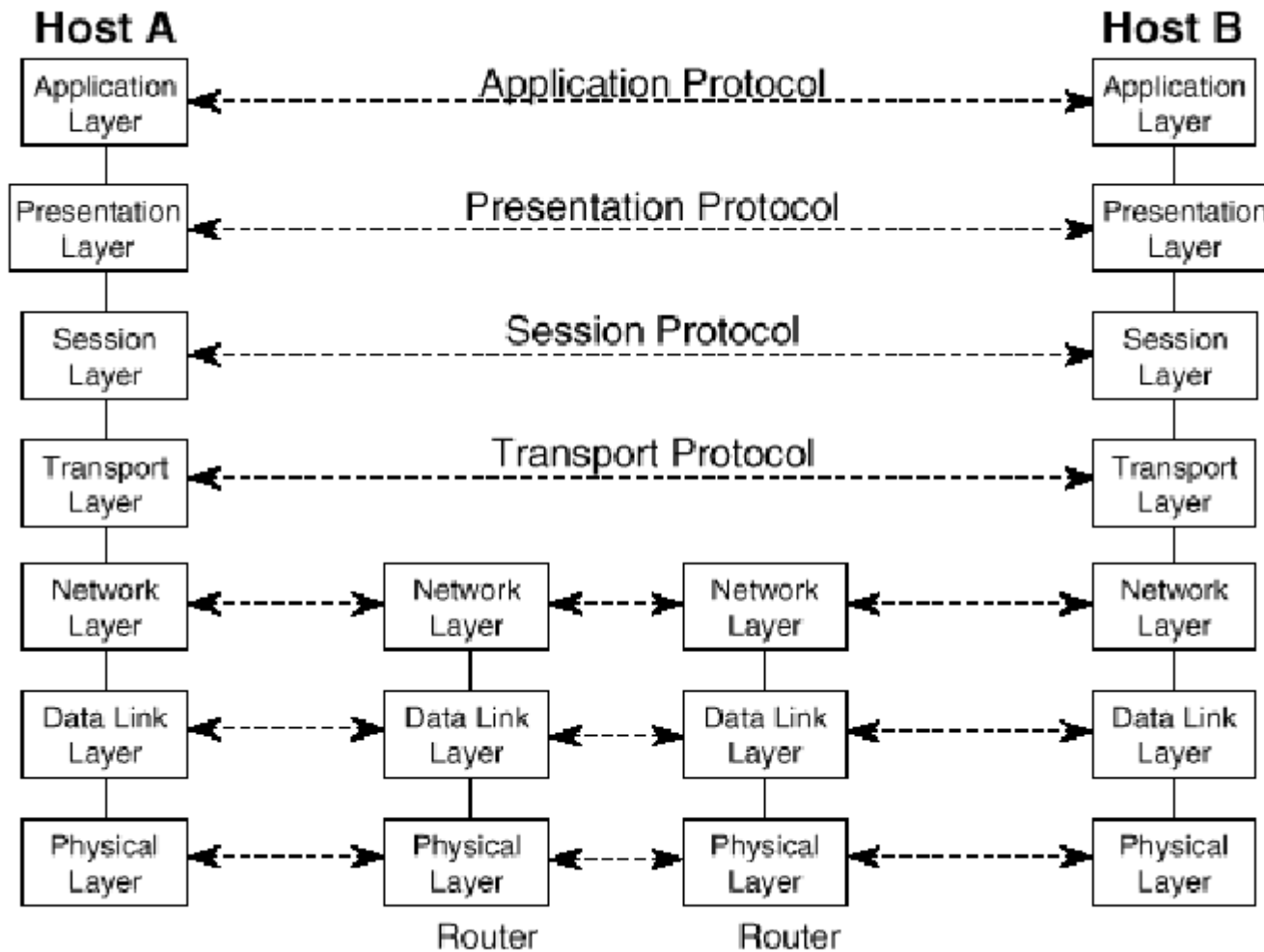
ISO: International Organization for Standardization



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

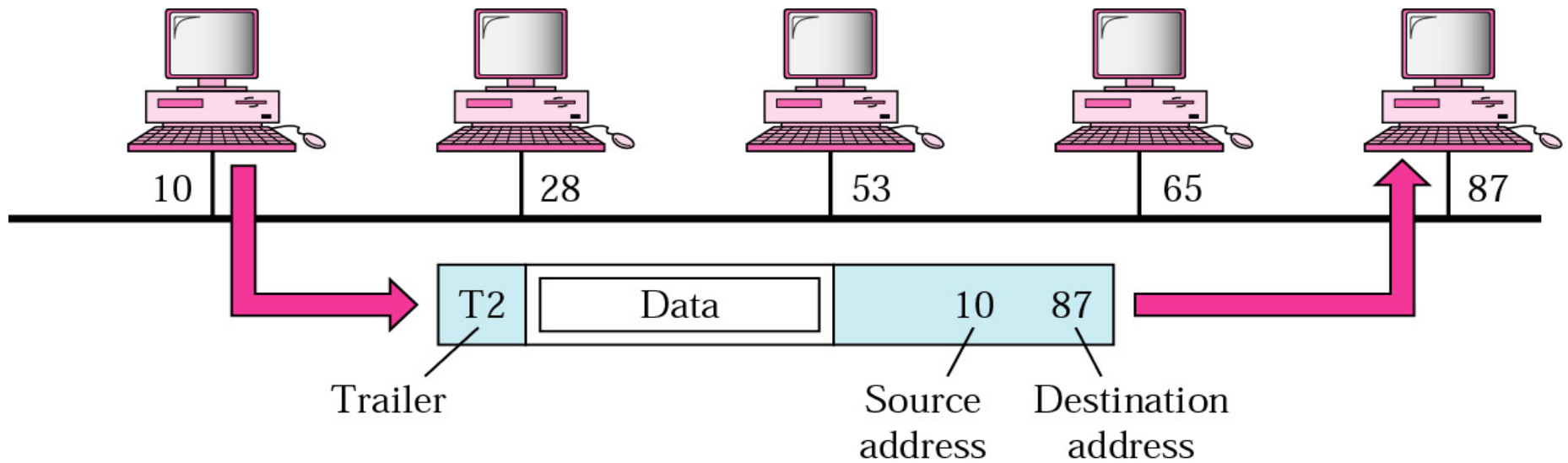
- Which modulation technique (bits to pulse (analog signal))?
- Which Line Coding technique (bits to digital signal?)
- How long will a bit last? (*bit interval vs bit rate*)
- Bit- serial or parallel transmission?
- Half- or Full- duplex transmission?
- How many pins does the network connector have?
- 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

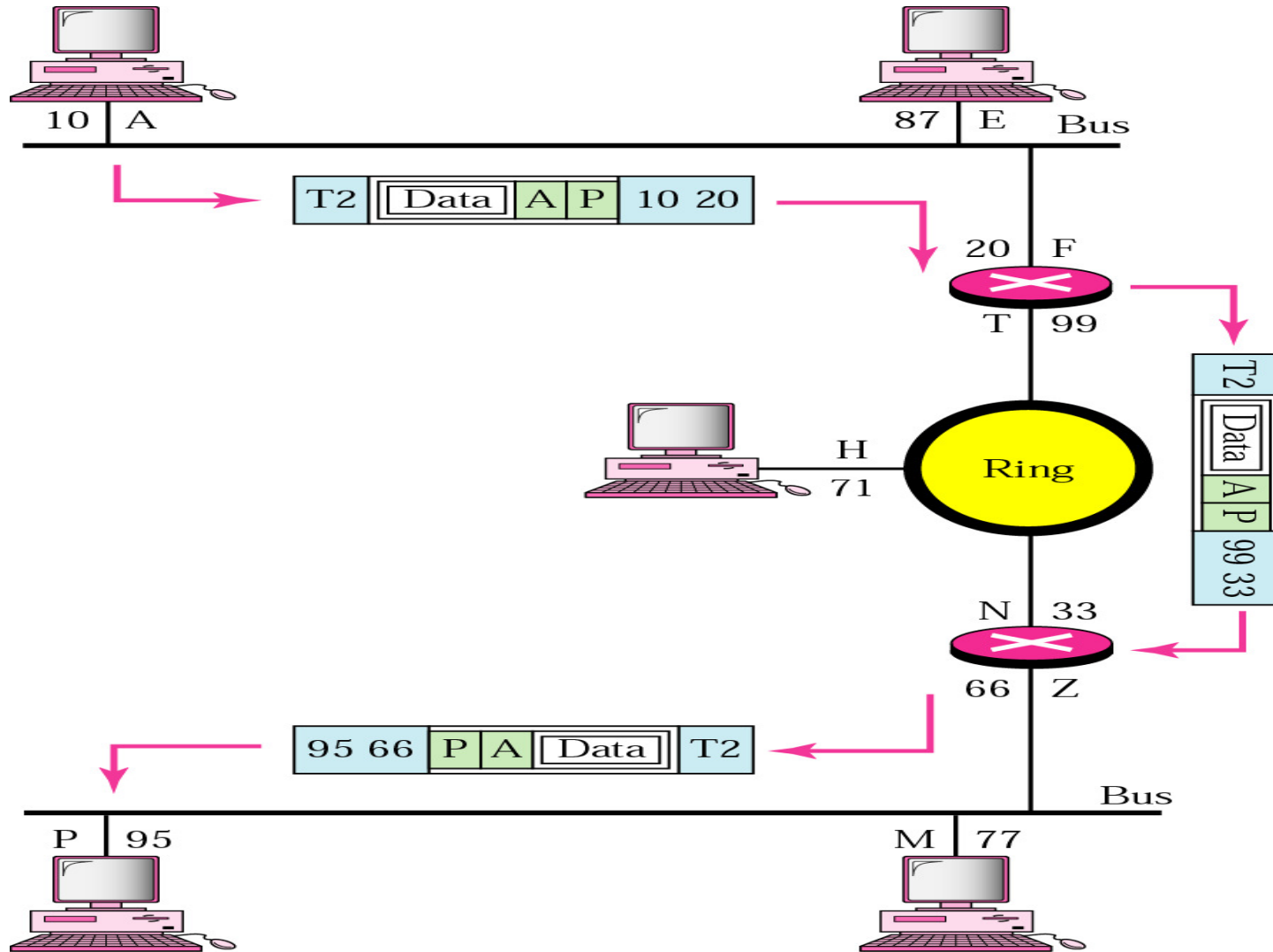


Network Layer ^{1/2}

•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”*