無線網路概論
Intro. to Wireless Internet

Lecture 01 - Communication Networks

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YZU CSE

Lecture Material

- "Wireless Communication Networks and Systems", Corry Beard and William Stallings, 2016.
  - Ch 3. Communication Networks
  - Ch 4. Protocols and the TCP/IP Suite

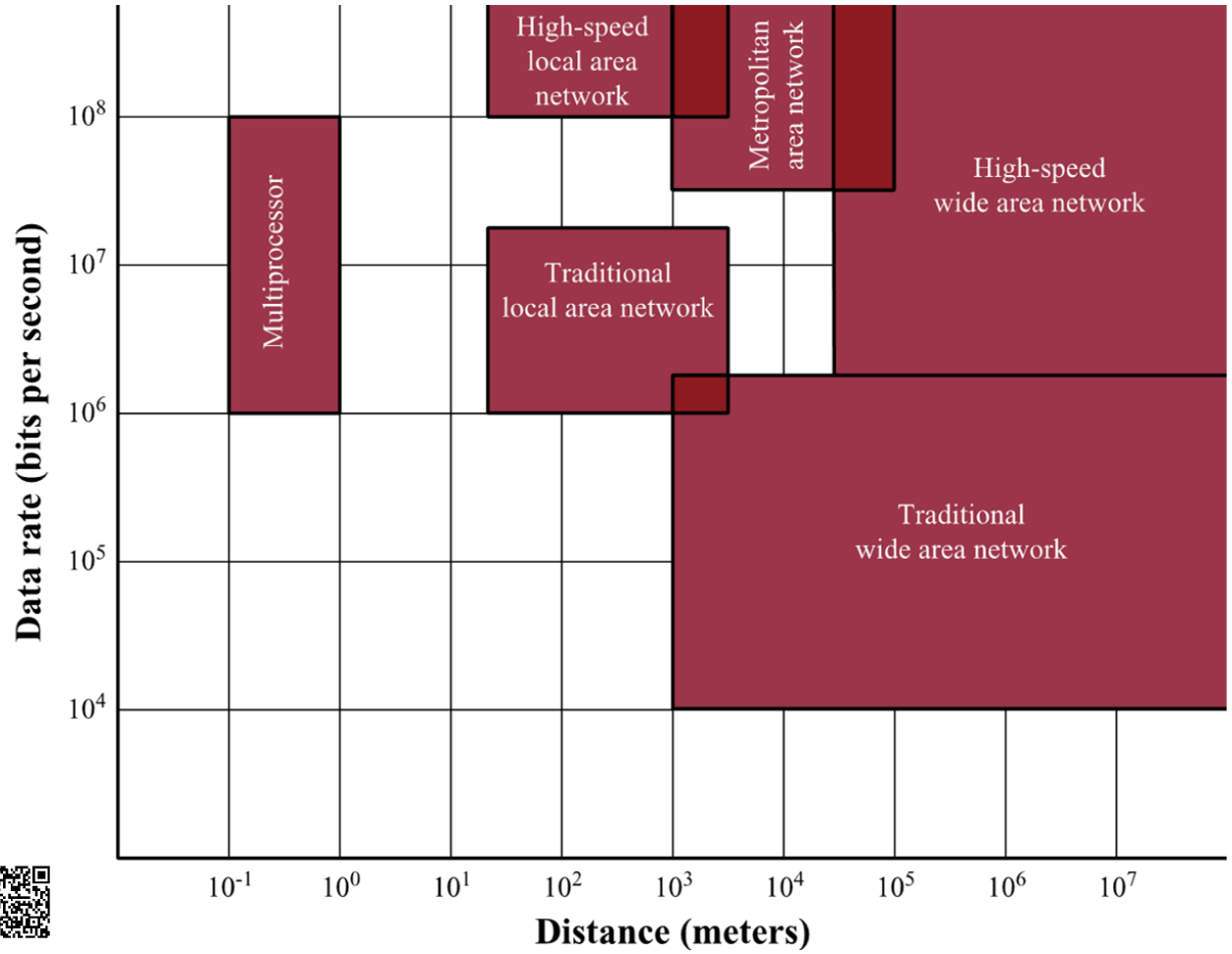
Outline

- Communication Networks
- Protocols

Outline

- Communication Networks
  - LANs, MANs, and WANs
  - Switching technologies
  - Circuit switching
  - Packet switching
  - Quality of service
- Protocols

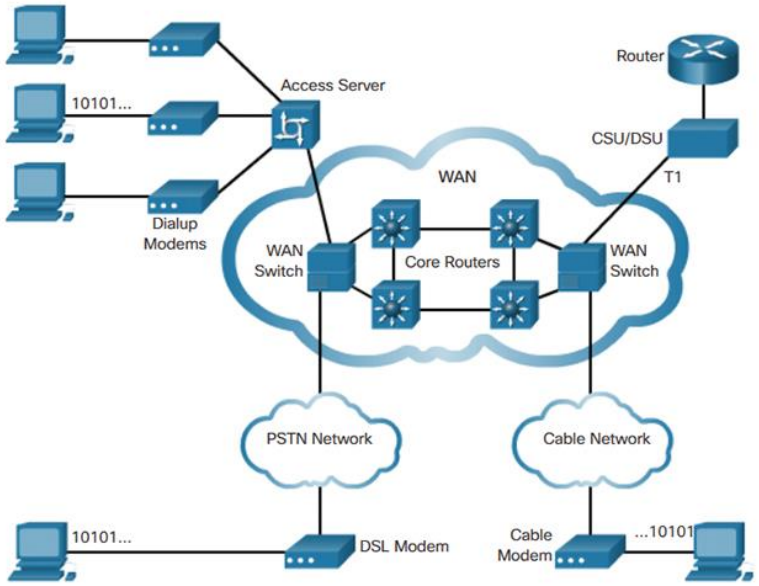
LANs, MANs, and WANs



- Traditional
  - Traditional local area network (LAN)
  - Traditional wide area network (WAN)
- Higher-speed
  - High-speed local area network (LAN)
  - Metropolitan area network (MAN)
  - High-speed wide area network (WAN)

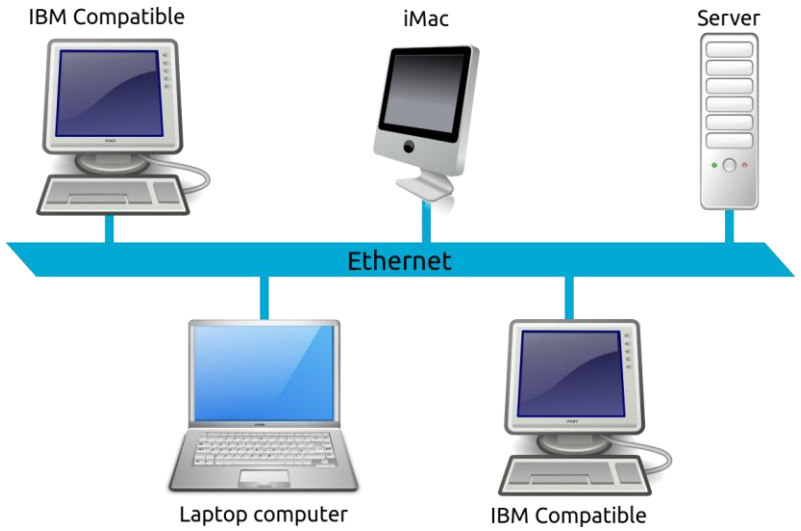
Characteristics of WANs

- Covers large geographical areas
- Circuits provided by a common carrier
- Consists of interconnected switching nodes
- Traditional WANs provided modest capacity
- Higher-speed WANs use optical fiber and transmission technique known as asynchronous transfer mode (ATM)
  - 10s and 100s of Mbps common



Characteristics of LANs

- Like WAN, LAN interconnects a variety of devices and provides a means for information exchange among them
- Traditional LANs
  - Provided data rates of 1 to 20 Mbps
- High-speed LANS
  - Provide data rates of 100 Mbps to 1 Gbps



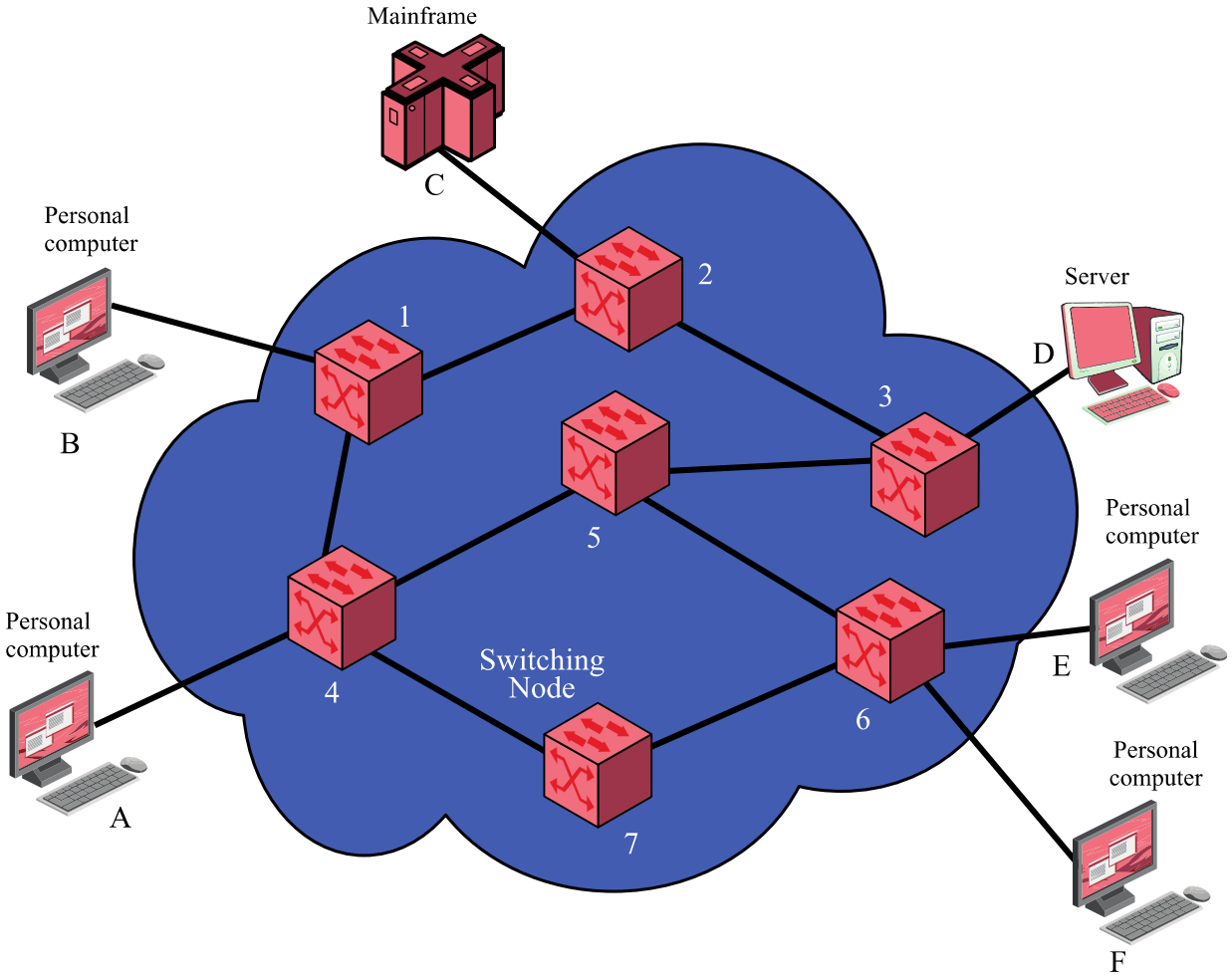
LANs vs. WANs

- Scope of a LAN is smaller
  - LAN interconnects devices within a single building or cluster of buildings
- LAN usually owned by organization that owns the attached devices
  - For WANs, most of network assets are not owned by same organization
- Internal data rate of LAN is much greater.

The Need for MANs

- Traditional point-to-point and switched network techniques used in WANs are inadequate for growing needs of organizations.
- Need for high capacity and low costs over large area. (private or public networks)
- MAN provides:
  - Service to customers in metropolitan areas
  - Required capacity
  - Lower cost and greater efficiency than equivalent service from telephone company

Simple Switching Network



- Switching Nodes:
  - Intermediate switching device that moves data.
  - Not concerned with content of data
- Stations:
  - End devices that wish to communicate.
  - Each station is connected to a switching node.
- Communications Network:
  - A collection of switching nodes

Observations

- Some nodes connect only to other nodes (e.g., 5 and 7).
- Some nodes connect to one or more stations.
- Node-station links usually dedicated point-to-point links.
- Node-node links usually multiplexed links
  - Frequency-division multiplexing (FDM)
  - Time-division multiplexing (TDM)
- Not a direct link between every node pair (not fully connected)

Techniques in Switched Networks (SN)

- Circuit switching
  - Dedicated communications path between two stations
  - e.g., public telephone network
- Packet switching
  - Message is broken into a series of packets.
  - Each node determines next leg of transmission for each packet.

Phases of Circuit Switching

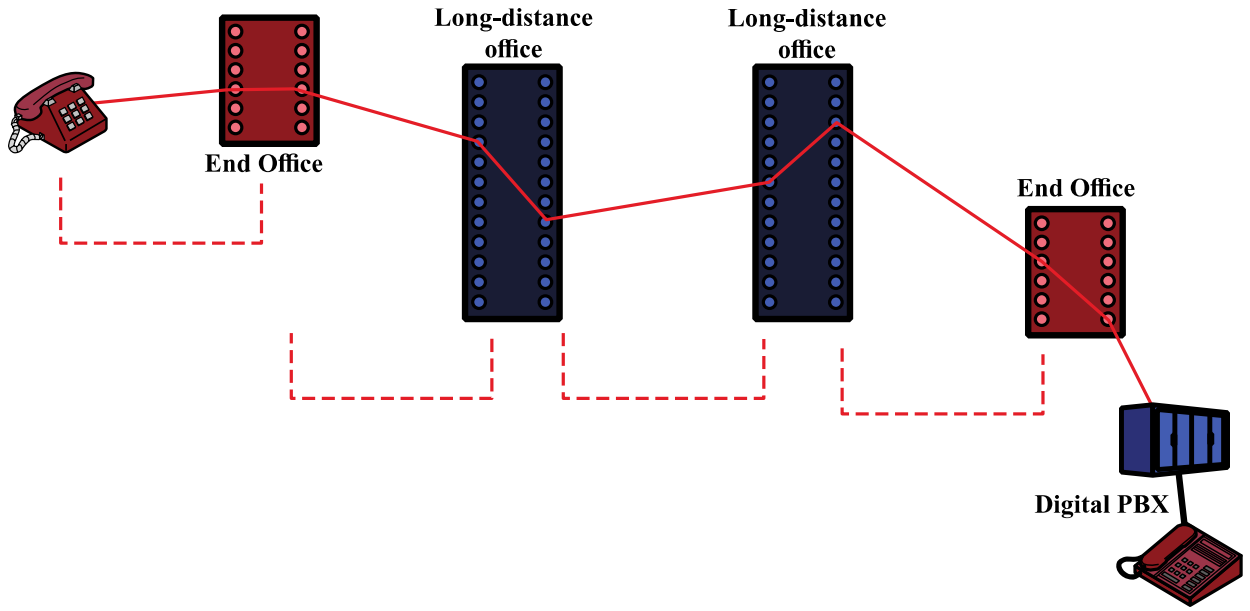
- Circuit establishment
  - An end to end circuit is established through switching nodes.
  - Test if the other end is busy or is prepared.
- Information transfer
  - Information transmitted through the network. (full duplex)
  - Data may be analog voice, digitized voice, or binary data.
- Circuit disconnect
  - Circuit is terminated.
  - Each node deallocates dedicated resources.

Characteristics of CS

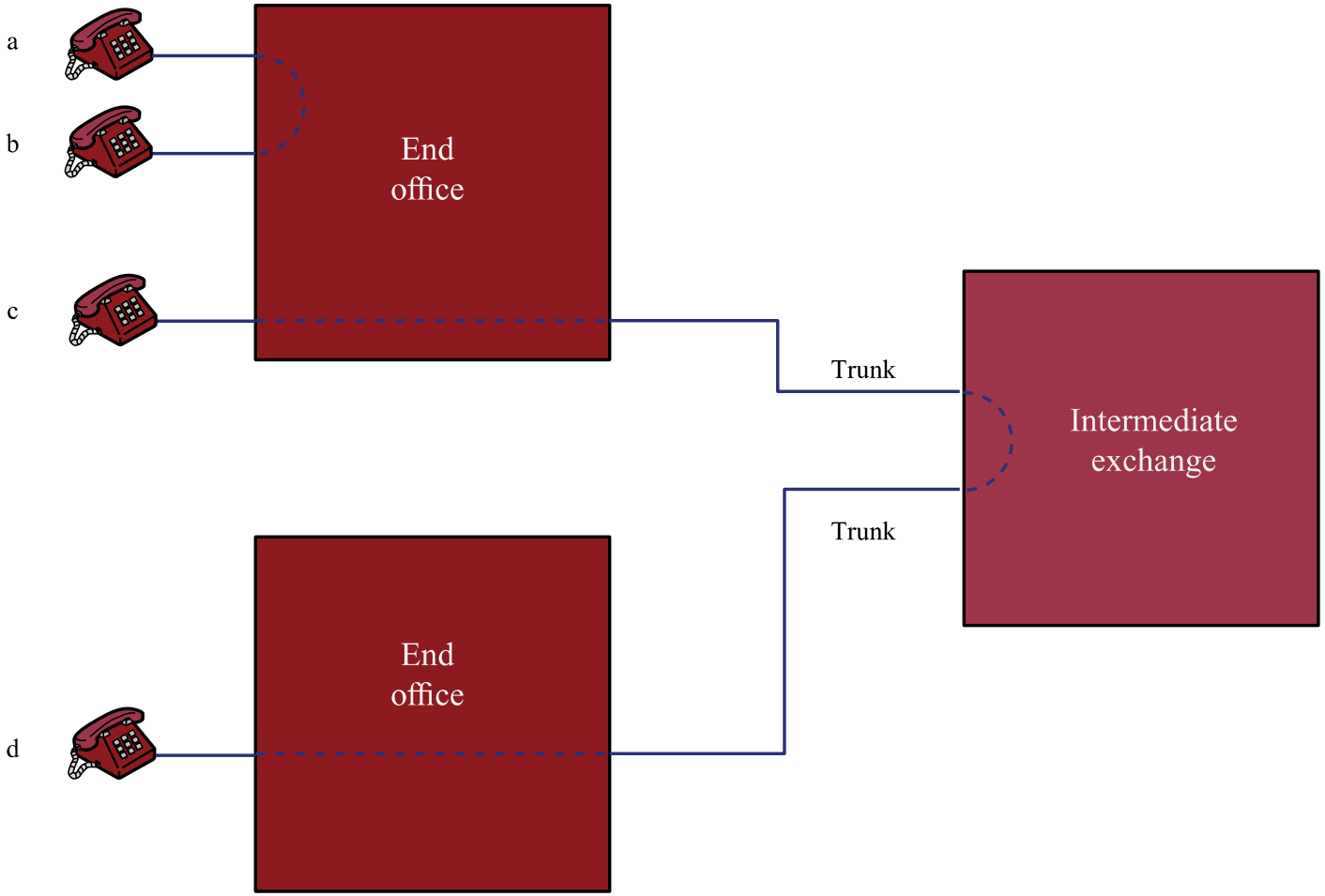
- Can be inefficient
  - Channel capacity dedicated for duration of connection
  - Utilization not 100%
  - Delay prior to signal transfer for establishment
- Once established, network is transparent to users.
- Information transmitted at fixed data rate with only propagation delay.

Public Telecomm. Network

- Subscribers - devices that attach to the network; mostly telephones
- Subscriber line - link between subscriber and network
  - Also called subscriber loop or local loop
- Exchanges - switching centers in the network
  - A switching center that support subscribers is an end office
- Trunks - branches between exchanges

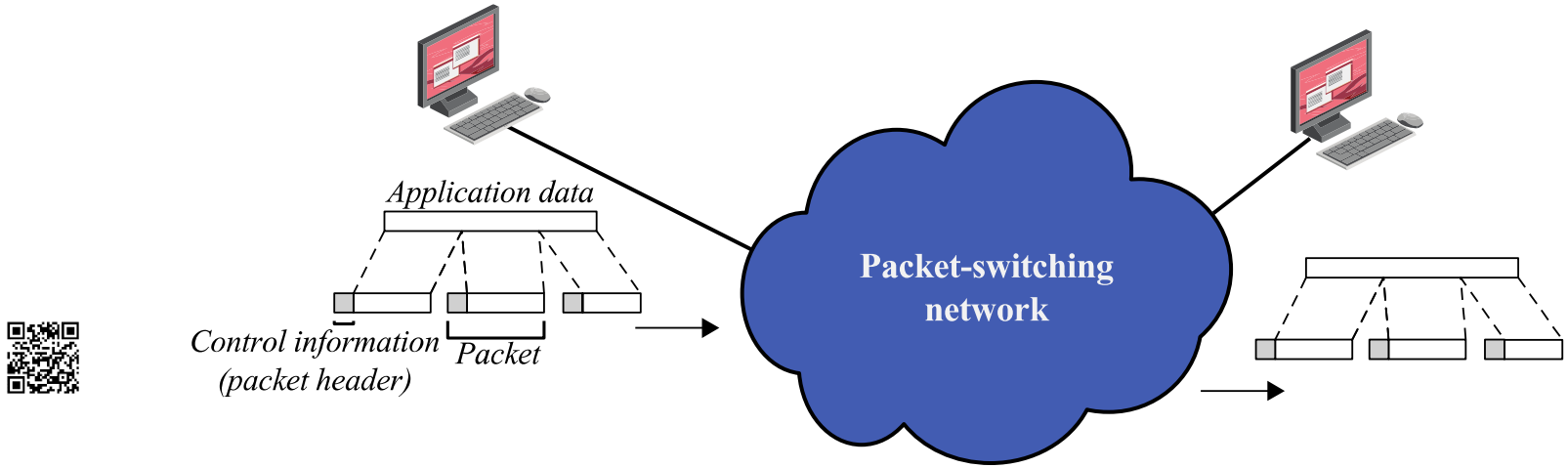


Circuit Establishment



How Packet Switching Works

- Data is transmitted in blocks, called packets
- Before sending, the message is broken into a series of packets
  - Typical upper bound on packet length is 1500 octets (bytes).
  - Packets consists of a portion of data plus a packet header that includes control information
- At each node in route, packet is received, stored briefly and passed to the next node.



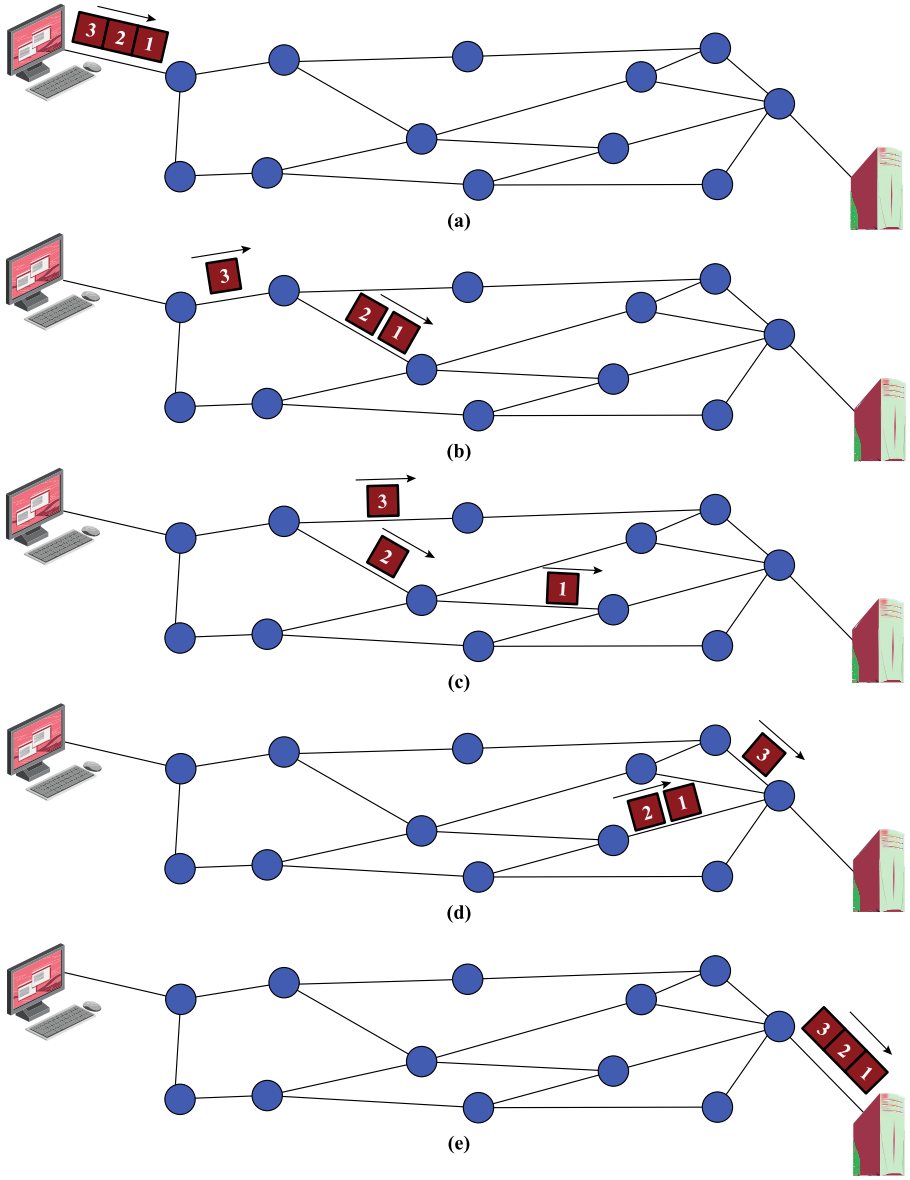
Advantages of PS

- Line efficiency is greater.
  - Many packets over time can dynamically share the same node to node link.
- Packet-switching networks can carry out data-rate conversion.
  - Two stations with different data rates can exchange information
- Unlike circuit-switching networks that block calls when traffic is heavy, packet-switching still accepts packets, but with increased delivery delay.
- Priorities can be used.

Disadvantages of PS

- Each packet switching node introduces a delay.
- Overall packet delay can vary substantially
  - This is referred to as jitter.
  - Caused by differing packet sizes, routes taken and varying delay in the switches.
- Each packet requires overhead information.
  - Includes destination and sequencing information.
  - Reduces communication capacity.
- More processing required at each node.

PSNs - Datagram

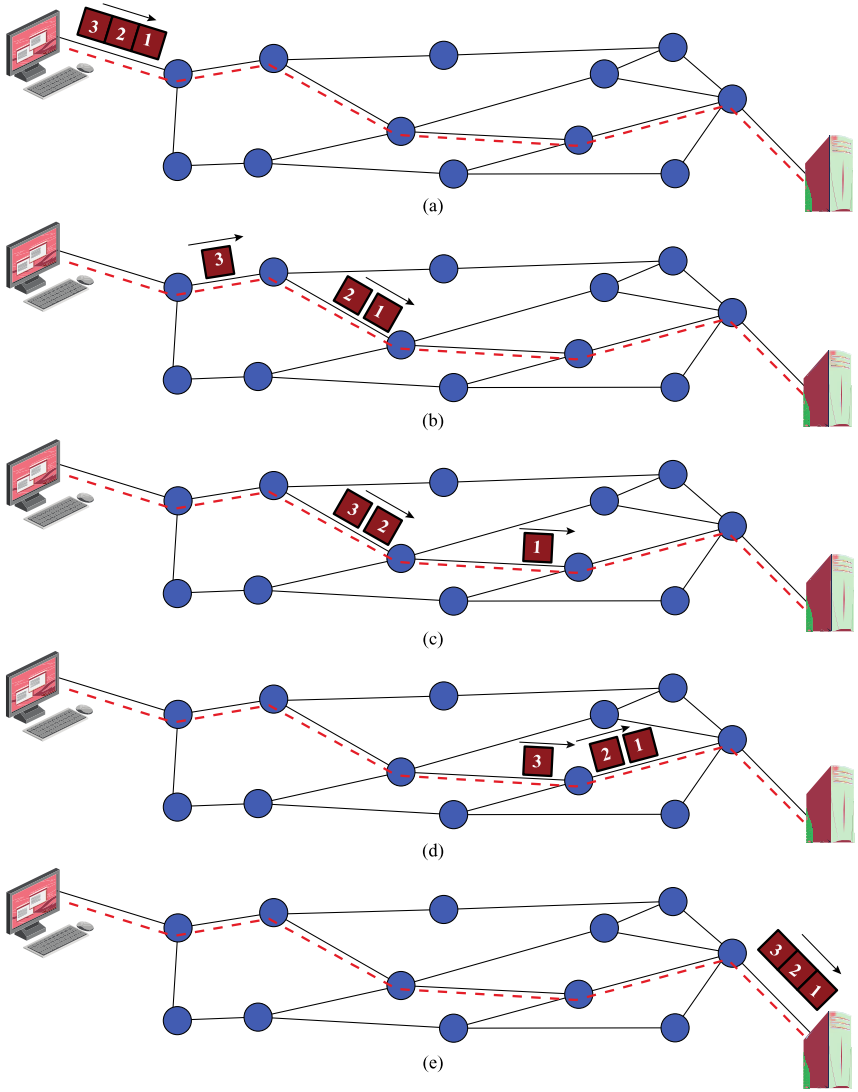


- Each packet treated independently, without reference to previous packets
- Each node chooses next node on packet's path.
- Packets don't necessarily follow same route and may arrive out of sequence.
- Exit node restores packets to original order.
- Responsibility of exit node or destination to detect loss of packet and how to recover.

PSNs - Datagram

- Advantages:
  - Call setup phase is avoided
  - Because it’s more primitive, it’s more flexible.
  - Datagram delivery is more reliable.

PSNs – Virtual Circuit



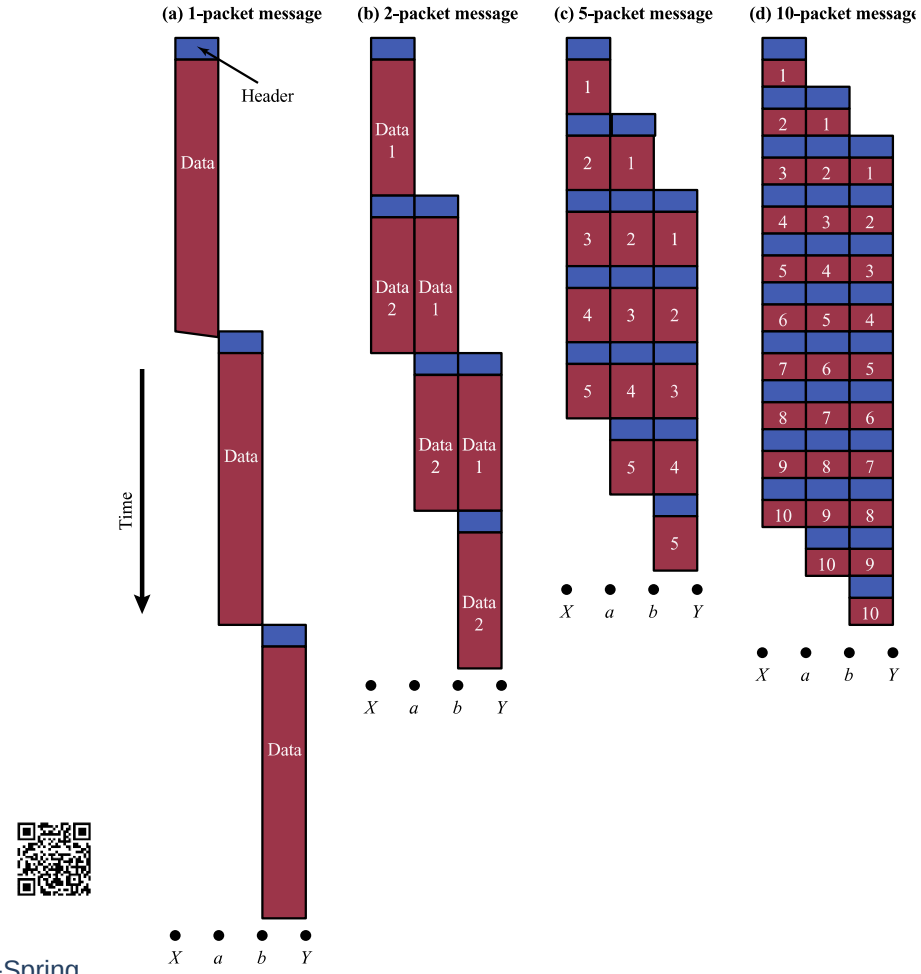
- Preplanned route established before packets sent.
- All packets between source and destination follow this route.
- Routing decision not required by nodes for each packet.
- Emulates a circuit in a circuit switching network but is not a dedicated path.
  - Packets still buffered at each node and queued for output over a line.

PSNs – Virtual Circuit

- Advantages:
  - Packets arrive in original order.
  - Packets arrive correctly.
  - Packets transmitted more rapidly without routing decisions made at each node.

Effect of Packet Size

- Breaking up packets decreases transmission time because transmission is allowed to overlap.



(a)
Entire message (40 octets) + header information (3 octets) sent at once
Transmission time: 129 octet-times

43*(3+0) octet-times

(b)
Message broken into 2 packets (20 octets) + header (3 octets)
Transmission time: 92 octet-times

23*(3+1) octet-times

(c)
Message broken into 5 packets (8 octets) + header (3 octets)
Transmission time: 77 octet-times

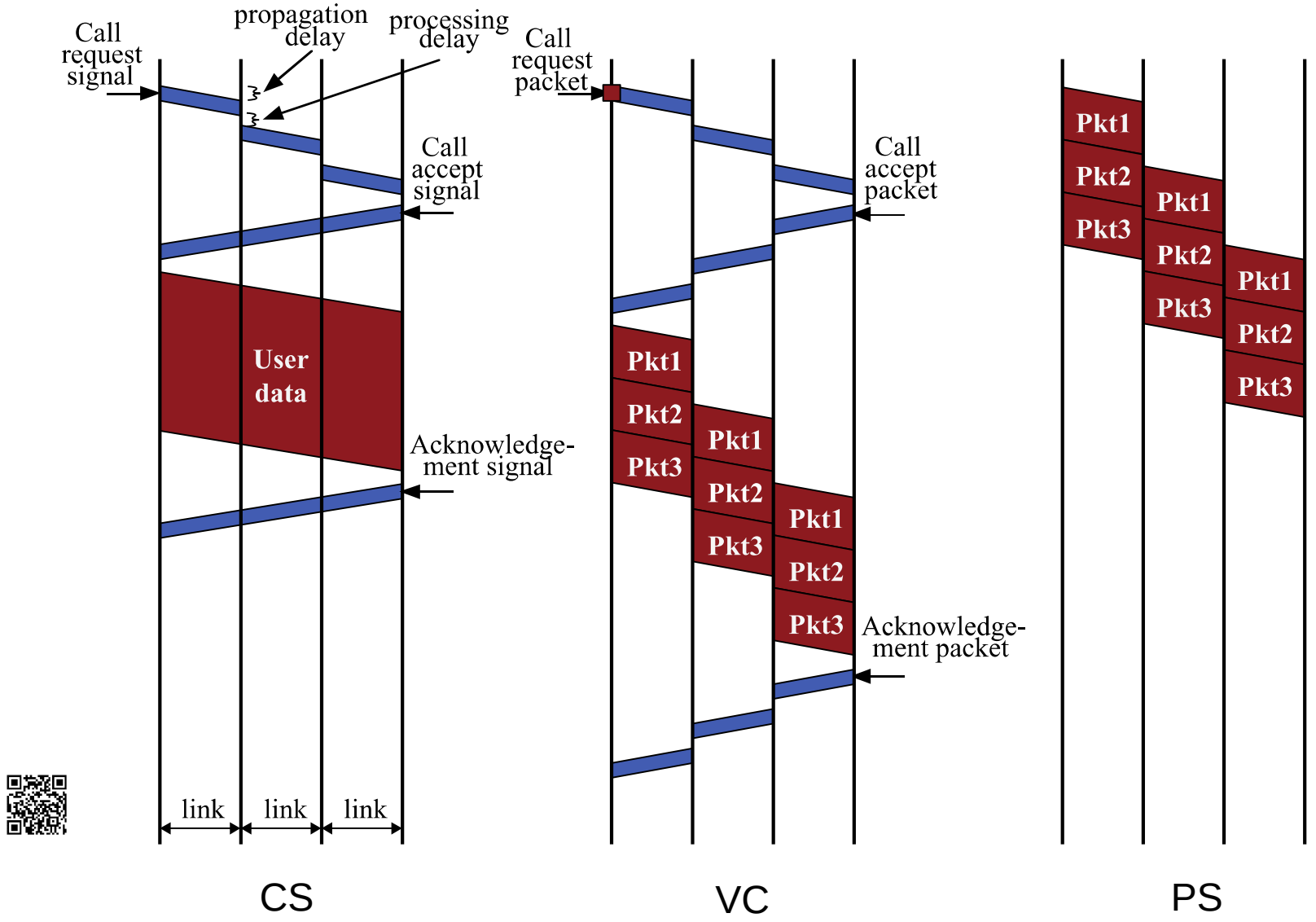
11*(3+4) octet-times

(d)
Making the packets too small, transmission time starts increases.

Comparison of CS and PS

- Performance
  - Propagation delay: a signal to propagate from one node to the next
  - Transmission time: for a transmitter to send out a block of data
  - Node delay: for a node to perform the necessary processing

Event Timing for CS and PS



Quality of Service

- Voice, Audio, and Video Traffic
  - Requirements
    - Steady delivery
    - Bounds on delay, delay variation, and minimal throughput
    - Some packet loss is acceptable.
  - Types
    - Streaming live video – such as a live sporting event
    - Streaming stored video – such as Youtube, that uses buffering
    - Video conferencing – interactive and has additional requirements for round-trip delay

Quality of Service

- Data Traffic
  - Requirements
    - Eventual error-free delivery
      - After retransmissions
    - More desirable the higher the throughput
    - Elastic
      - Some variation in throughput is acceptable during a transmission
  - Types
    - Interactive – such as transactions or web page interactions
    - Non-interactive – background downloads of files or email

Provisioning of QoS

- Overprovisioning
  - High data rates and low congestion
  - No prioritization
  - All traffic proceeds virtually unimpeded
  - Only practical in wireless systems that have abundant bandwidth
- Prioritization without guarantees
  - Some packets marked as higher priority.
  - Admission control processes are used to identify users and flows that should receive this priority.
  - Various markings are used for different technologies (e.g., LTE, WiMAX)
- Prioritization with guarantees
  - Packets are tracked
  - Given numerical bounds on performance
  - Admission control also important here

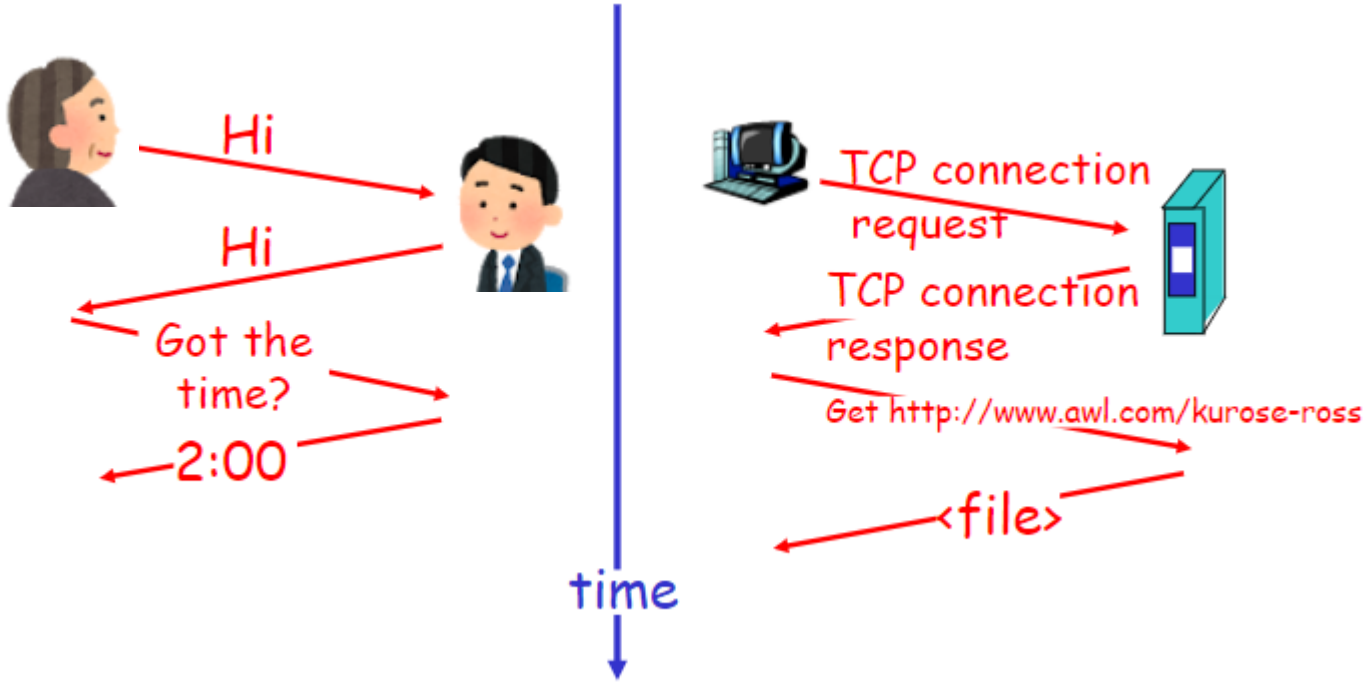
Learning Objectives

- After studying this chapter, you should be able to:
  - Explain the roles and scope of wide, local, and metropolitan area networks.
  - Define circuit switching and describe the key elements of circuit-switching networks.
  - Define packet switching and describe the key elements of packet-switching technology.
  - Discuss the relative merits of circuit switching and packet switching and analyze the circumstances for which each is most appropriate.

Outline

- Communication Networks
- Protocols
  - The need for a protocol architecture
  - The TCP/IP protocol architecture
  - The OSI model
  - Internetworking

Protocol



- Protocol architecture
  - Each layer in the stack performs a related subset of the functions required to communicate with another system.
- The peer layers communicate by formatted blocks of data that obey a set of rules or conventions (protocol).

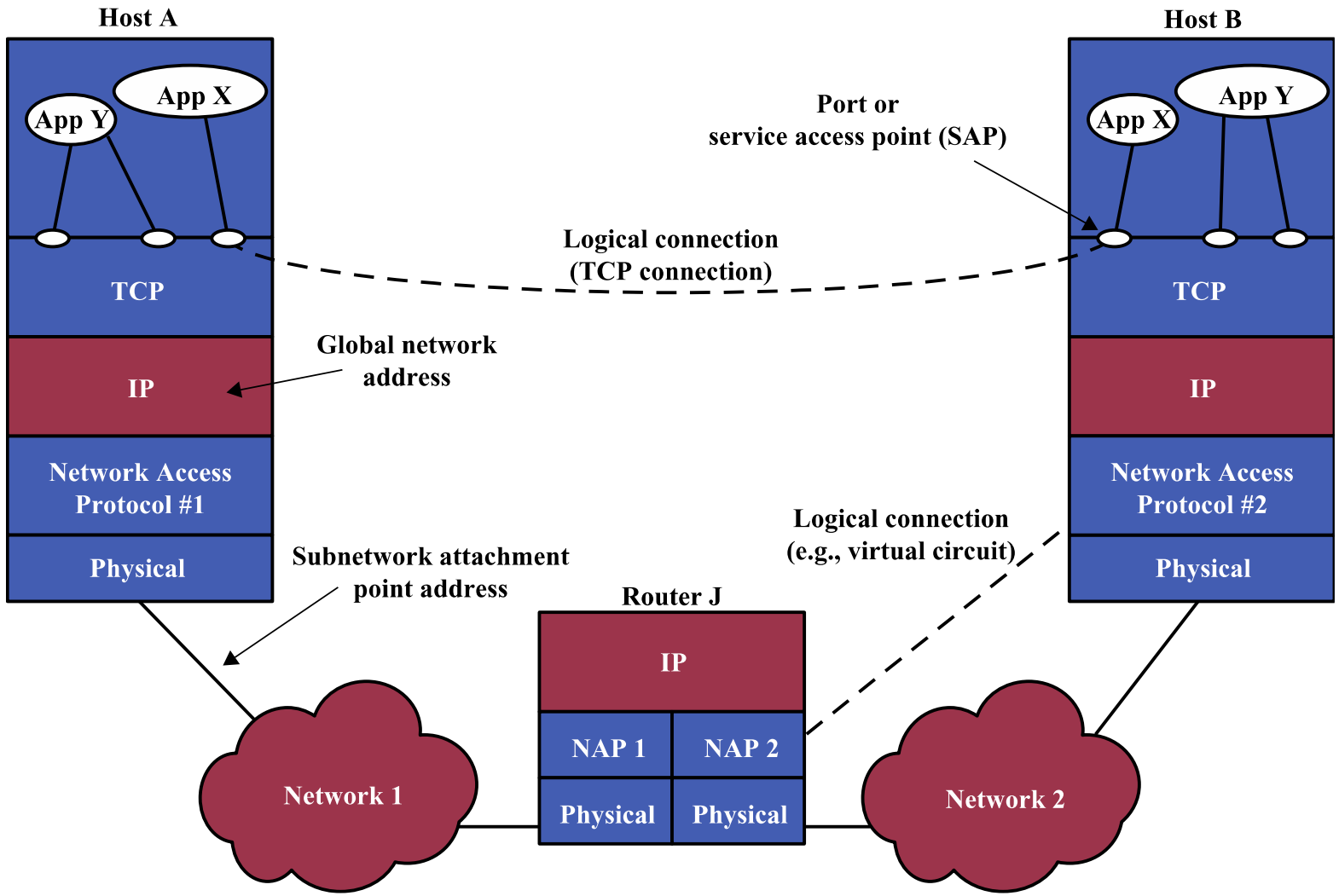
Key Features of a Protocol

- Syntax
  - Concerns the format of the data blocks
- Semantics
  - Includes control information for coordination and error handling
- Timing
  - Includes speed matching and sequencing

Agents in Comm.

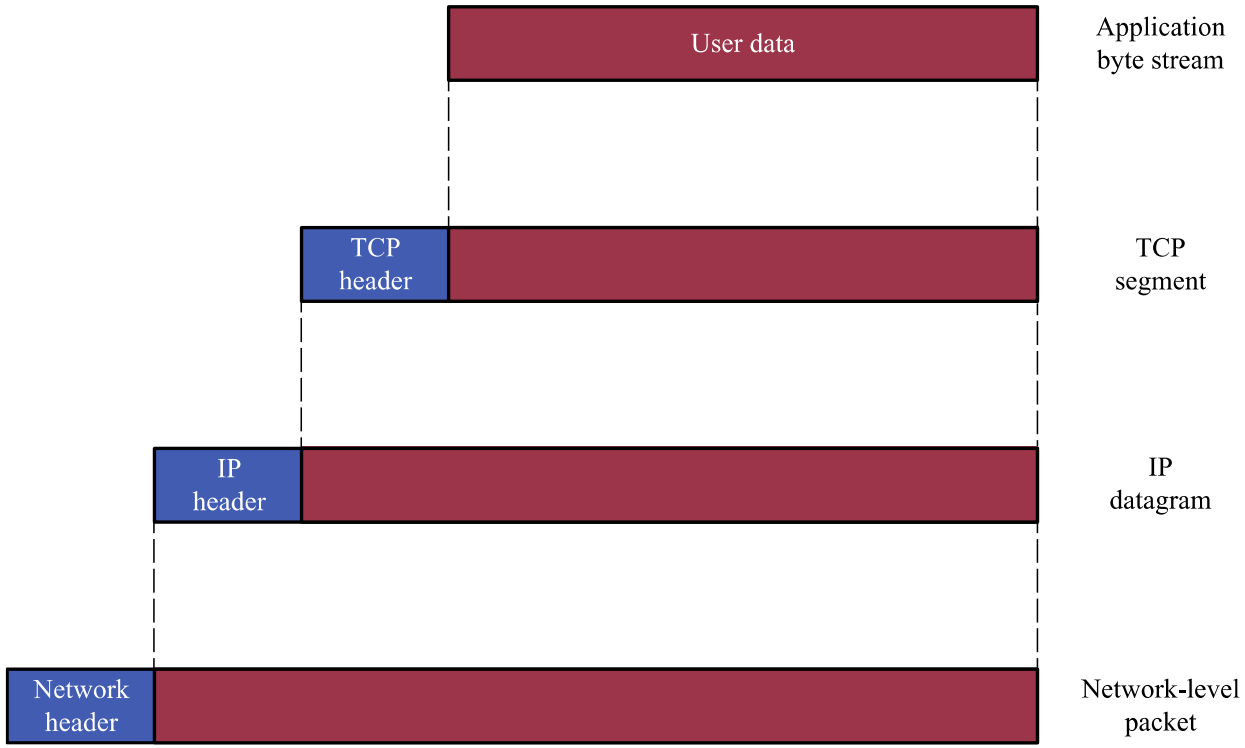
- Applications
  - Exchange data between computers (e.g., electronic mail)
- Computers
  - Connected to networks
- Networks
  - Transfers data from one computer to another

TCP/IP Concepts



TCP/IP Layers

- Physical layer
- Network access layer
- Internet layer
- Host-to-host, or transport layer
- Application layer



Protocol Data Unit (PDU)

TCP/IP Physical Layer

- Covers the physical interface between a data transmission device and a transmission medium or network.
- Physical layer specifies:
  - Characteristics of the transmission medium
  - The nature of the signals
  - The data rate
  - Other related matters

TCP/IP Network Access Layer

- Concerned with the exchange of data between an end system and the network to which it's attached
- Software used depends on type of network
  - Circuit switching
  - Packet switching (e.g., X.25)
  - LANs (e.g., Ethernet)
  - Others

TCP/IP Internet Layer

- Uses internet protocol (IP)
- Provides routing functions to allow data to traverse multiple interconnected networks
- Implemented in end systems *and* routers

Five Different Classes of IPv4 Addresses

Class	First Octet decimal (range)	First Octet binary (range)	IP range	Subnet Mask	Hosts per Network ID	# of networks
Class A	0 – 127	0XXXXXXX	0.0.0.0-127.255.255.255	255.0.0.0	$2^{24}-2$	2^{7}
Class B	128 – 191	10XXXXXX	128.0.0.0-191.255.255.255	255.255.0.0	$2^{16}-2$	2^{14}
Class C	192 – 223	110XXXXX	192.0.0.0-223.255.255.255	255.255.255.0	$2^{8}-2$	2^{21}
Class D (Multicast)	224 – 239	1110XXXX	224.0.0.0-239.255.255.255			
Class E (Experimental)	240 – 255	1111XXXX	240.0.0.0-255.255.255.255			

TCP/IP Transport Layer

- Commonly uses transmission control protocol (TCP)
- Provides reliability during data exchange
  - Completeness
  - Order

TCP/IP Application Layer

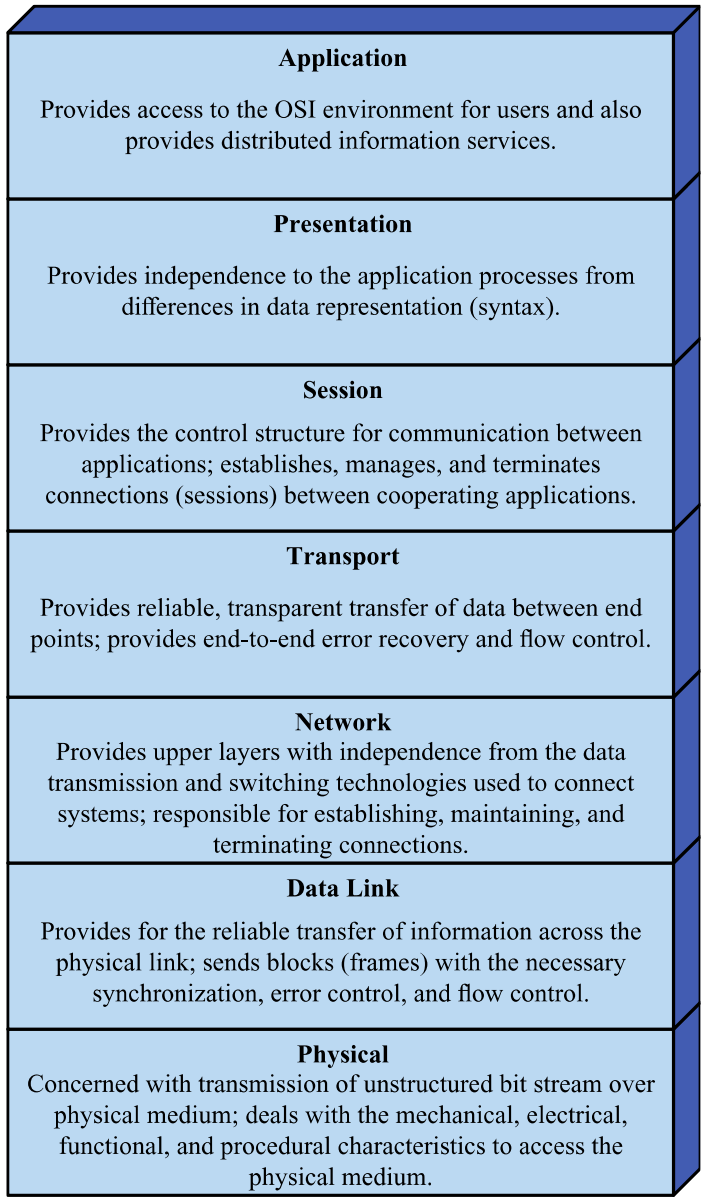
- Logic supports user applications
- Uses separate modules that are peculiar to each different type of application

Common TCP/IP Applications

- Simple mail transfer protocol (SMTP)
  - Provides a basic electronic mail facility
- File Transfer Protocol (FTP)
  - Allows files to be sent from one system to another
- Hypertext Transfer Protocol (HTTP)
  - Transfers information for the World Wide Web

Layers of the OSI Model

- Open Systems Interconnection (OSI) model
  - Application
  - Presentation
  - Session
  - Transport
  - Network
  - Data link
  - Physical



OSI Application Layer

- Provides access to the OSI environment for users
- Provides distributed information services

OSI Presentation Layer

- Provides independence to the application processes from differences in data representation (syntax)

OSI Session Layer

- Provides the control structure for communication between applications
- Establishes, manages, and terminates connections (sessions) between cooperating applications

OSI Transport Layer

- Provides reliable, transparent transfer of data between end points
- Provides end-to-end error recovery and flow control

OSI Network Layer

- Provides upper layers with independence from the data transmission and switching technologies used to connect systems
- Responsible for establishing, maintaining, and terminating connections

OSI Data link Layer

- Provides for the reliable transfer of information across the physical link
- Sends blocks (frames) with the necessary synchronization, error control, and flow control

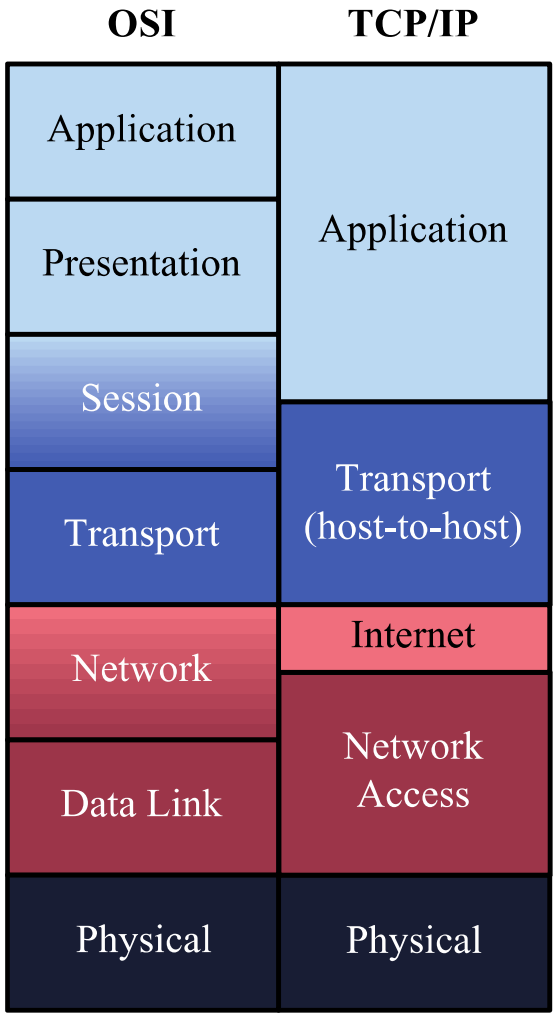
OSI Physical Layer

- Concerned with transmission of unstructured bit stream over physical medium
- Deals with accessing the physical medium
  - Mechanical characteristics
  - Electrical characteristics
  - Functional characteristics
  - Procedural characteristics

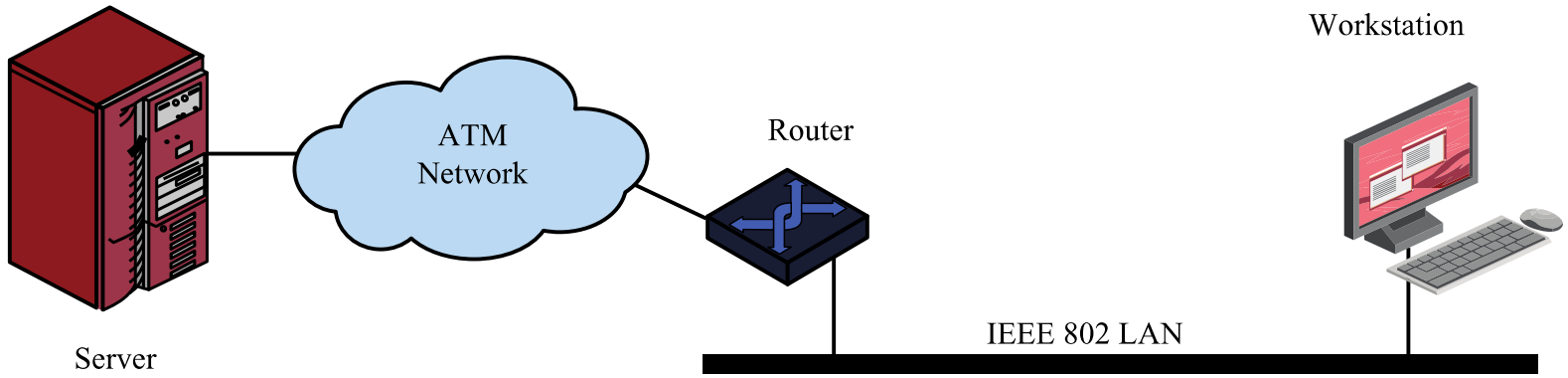
TCP/IP Architecture Dominance

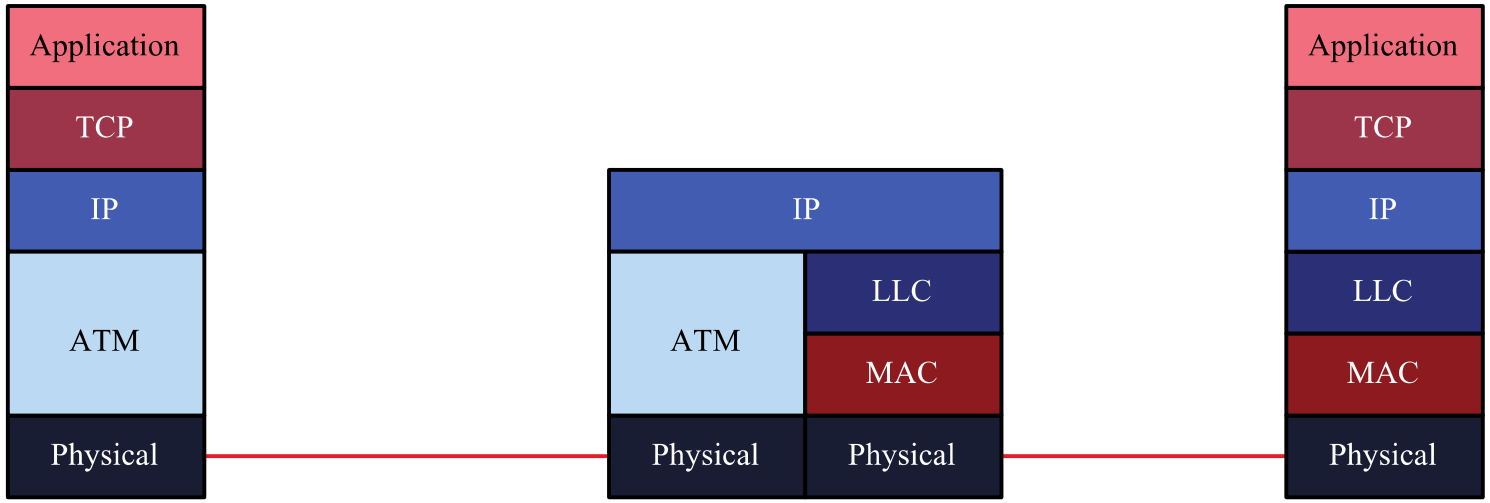
- TCP/IP protocols matured quicker than similar OSI protocols
  - When the need for interoperability across networks was recognized, only TCP/IP was available and ready to go
- OSI model is unnecessarily complex
  - Accomplishes in seven layers what TCP/IP does with fewer layers

OSI vs. TCP/IP


OSI
TCP/IP
Application
Presentation
Session
Transport
Network
Data Link
Physical
Application
Transport (host-to-host)
Internet
Network Access
Physical

TCP/IP Example





Operation of TCP/IP

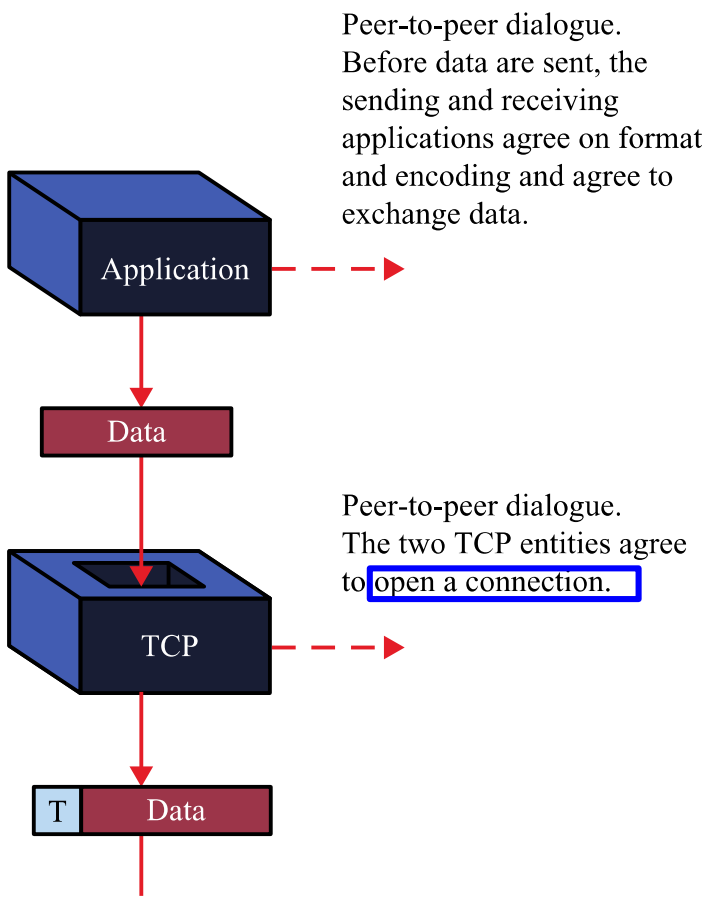
- Action at Sender (1/2)

1. Preparing the data. The application protocol prepares a block of data for transmission. For example, an email message (SMTP), a file (FTP), or a block of user input (TELNET).

2. Using a common syntax. If necessary, the data are converted to a form expected by the destination. This may include a different character code, the use of encryption, and/or compression.

3. Segmenting the data. TCP may break the data block into a number of segments, keeping track of their sequence. Each TCP segment includes a header containing a sequence number and a **frame check sequence** to detect errors.

4. Duplicating segments. A copy is made of each TCP segment, in case the loss or damage of a segment necessitates retransmission. When an acknowledgment is received from the other TCP entity, a segment is erased.

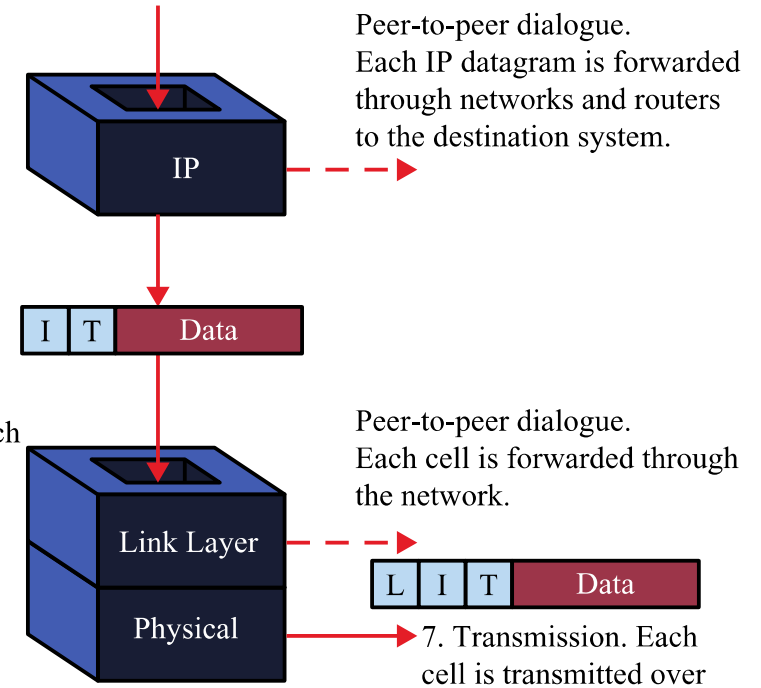


Operation of TCP/IP

- Action at Sender (2/2)

5. Fragmenting the segments. IP may break a TCP segment into a number of datagrams to meet size requirements of the intervening networks. Each datagram includes a header containing a destination address, a frame check sequence, and other control information.

6. Framing. A link layer header is added to each IP datagram to form a frame. The header contains a connection identifier and a header error control field.



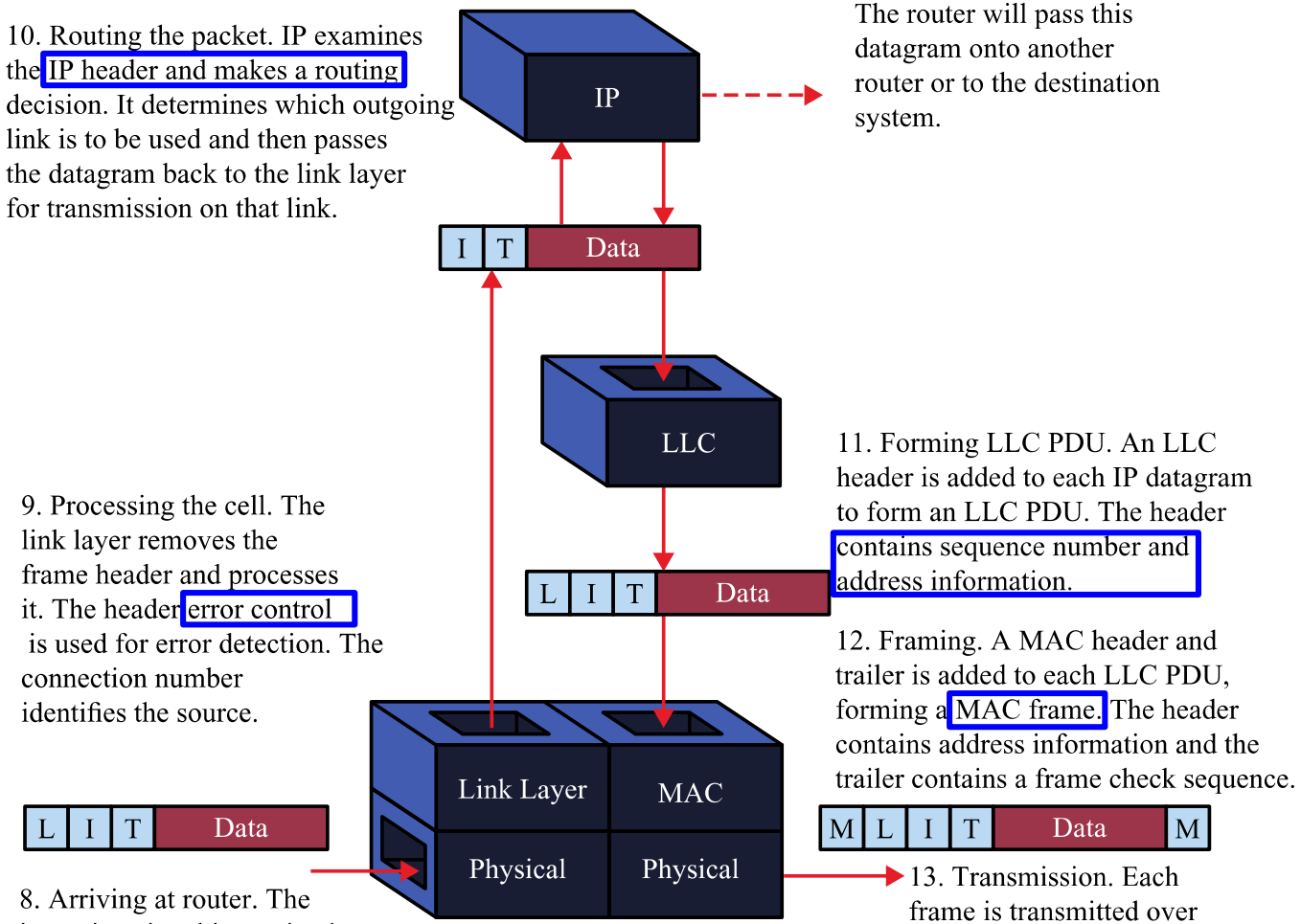
Peer-to-peer dialogue. Each IP datagram is forwarded through networks and routers to the destination system.

Peer-to-peer dialogue. Each cell is forwarded through the network.

7. Transmission. Each cell is transmitted over the medium as a sequence of bits.

Operation of TCP/IP

- Action at Router



Operation of TCP/IP

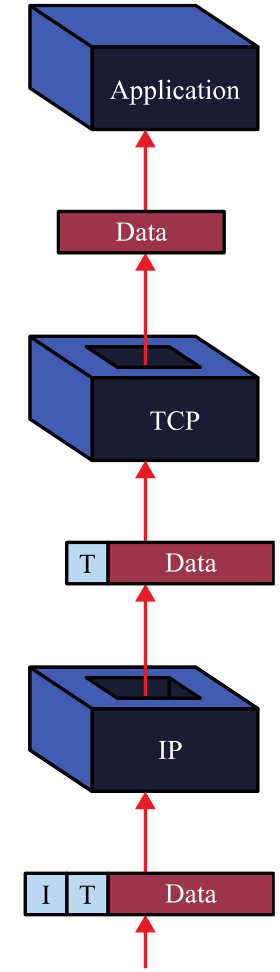
- Action at Receiver

20. Delivering the data. The application performs any needed transformations, including decompression and decryption, and directs the data to the appropriate file or other destination.

19. Reassembling user data. If TCP has broken the user data into multiple segments, these are reassembled and the block is passed up to the application.

18. Processing the TCP segment. TCP removes the header. It checks the frame check sequence and acknowledges if there is a match and discards for mismatch. Flow control is also performed.

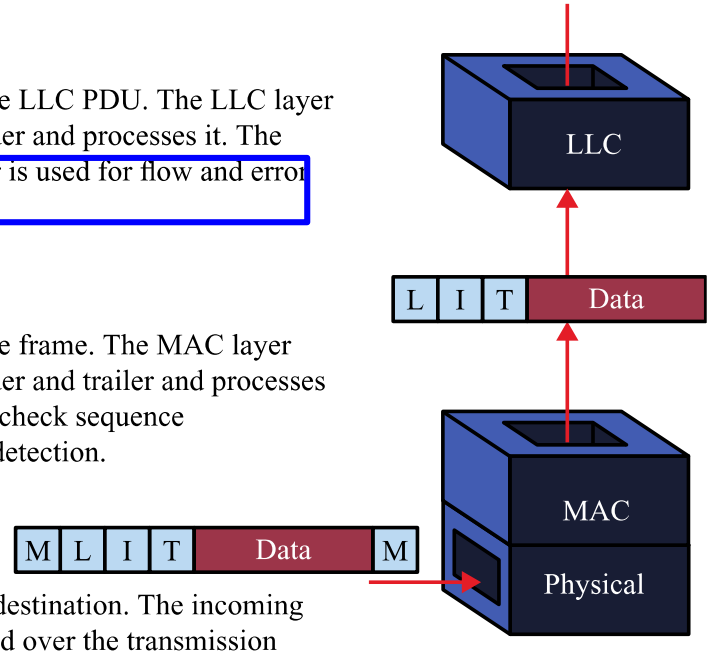
17. Processing the IP datagram. IP removes the header. The frame check sequence and other control information are processed.



16. Processing the LLC PDU. The LLC layer removes the header and processes it. The sequence number is used for flow and error control.

15. Processing the frame. The MAC layer removes the header and trailer and processes them. The frame check sequence is used for error detection.

14. Arriving at destination. The incoming signal is received over the transmission medium and interpreted as a frame of bits.



Elements of Standardization within OSI Framework

- Protocol Specification
  - Format of protocol data units (PDUs) exchanged
  - Semantics of all fields
  - Allowable sequence of PDUs
- Service Definition
  - Functional description that defines what services are provided, but not how the services are to be provided
- Addressing
  - Entities are referenced by means of a service access point (SAP)

Internetworking Terms

- Communication network – facility that provides a data transfer service among devices attached to the network
- Internet – collection of communication networks, interconnected by bridges/routers.
- Intranet – internet used by an organization for internal purposes.
  - Provides key Internet applications
  - Can exist as an isolated, self-contained internet.

Internetworking Terms

- End System (ES) – device used to support end-user applications or services
- Intermediate System (IS) – device used to connect two networks
- Bridge – an IS used to connect two LANs that use similar LAN protocols
- Router - an IS used to connect two networks that may or may not be similar

Functions of a Router

- Provide a link between networks
- Provide for the routing and delivery of data between processes on end systems attached to different networks
- Provide these functions in such a way as not to require modifications of the networking architecture of any of the attached subnetworks

Network Differences Routers Must Accommodate

- Addressing schemes
  - Different schemes for assigning addresses
- Maximum packet sizes
  - Different maximum packet sizes requires segmentation
- Interfaces
  - Differing hardware and software interfaces
- Reliability
  - Network may provide unreliable service

Learning Objectives

- After studying this chapter, you should be able to:
  - Describe the importance and objectives of a layered protocol architecture.
  - Explain the process of protocol encapsulation where PDUs are handed to different layers and headers are added for control purposes.
  - Describe the TCP/IP architecture and explain the functioning of each layer.
  - Explain the need for internetworking.
  - Describe the operation of a router within the context of TCP/IP to provide internetworking.