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Lecture 3: Networks and Protocols

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Slides are a selection from the slides from chapter 3 and 4 from:
http://williamstallings.com/Wireless/Wireless2e.html

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Switching Terms

- 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

[Stallings., 2005]

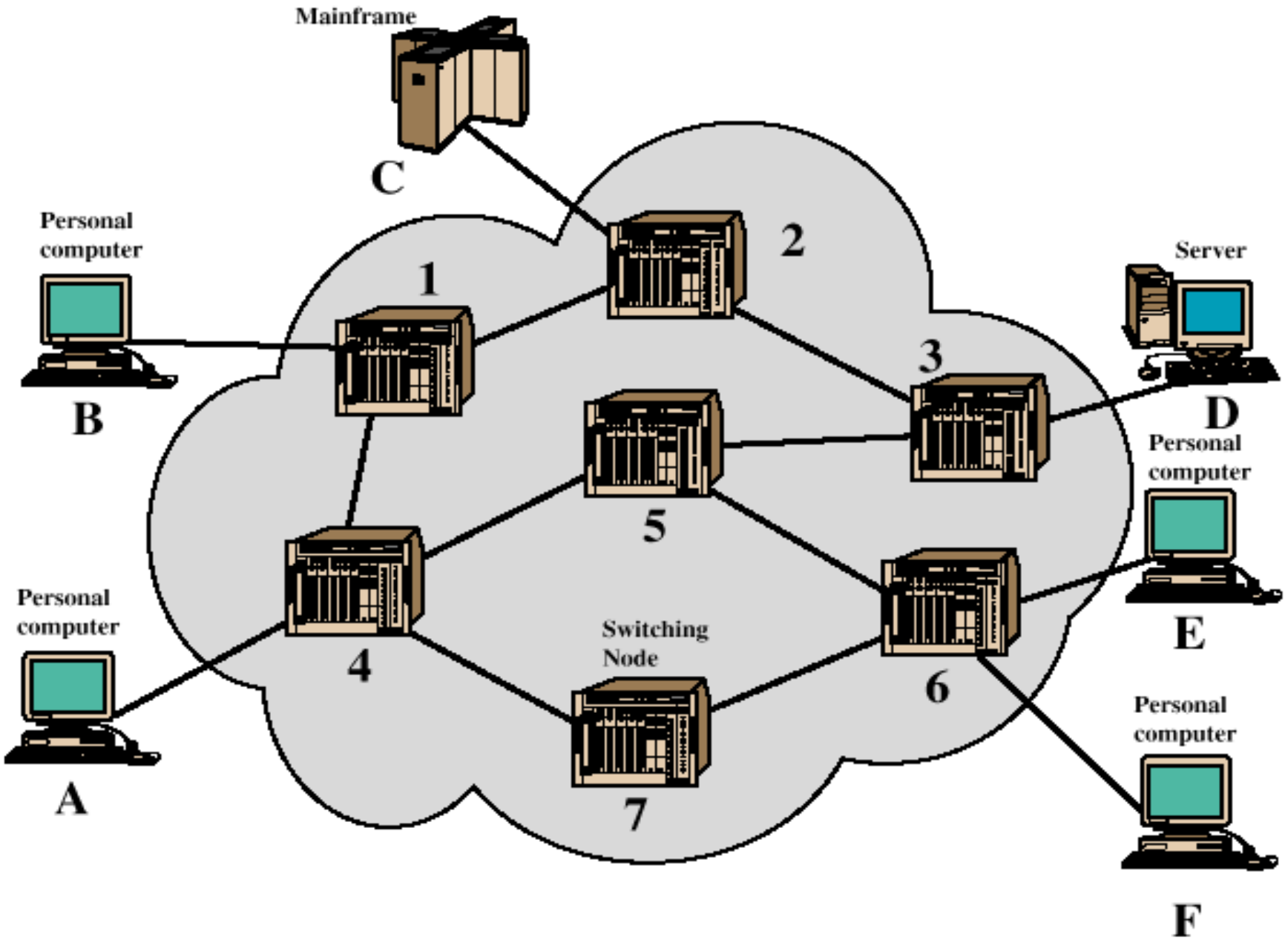

Figure 3.3 Simple Switching Network

[Stallings., 2005]

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Observations of Figure 3.3

- 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

[Stallings., 2005]

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Techniques Used in Switched Networks

- 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

[Stallings., 2005]

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Phases of Circuit Switching

- Circuit establishment
  - An end to end circuit is established through switching nodes
- Information Transfer
  - Information transmitted through the network
  - Data may be analog voice, digitized voice, or binary data
- Circuit disconnect
  - Circuit is terminated
  - Each node deallocates dedicated resources

[Stallings., 2005]

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Characteristics of Circuit Switching

- 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

[Stallings., 2005]

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Components of Public Telecommunications 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 centers that support subscribers is an end office
- Trunks - branches between exchanges

[Stallings., 2005]

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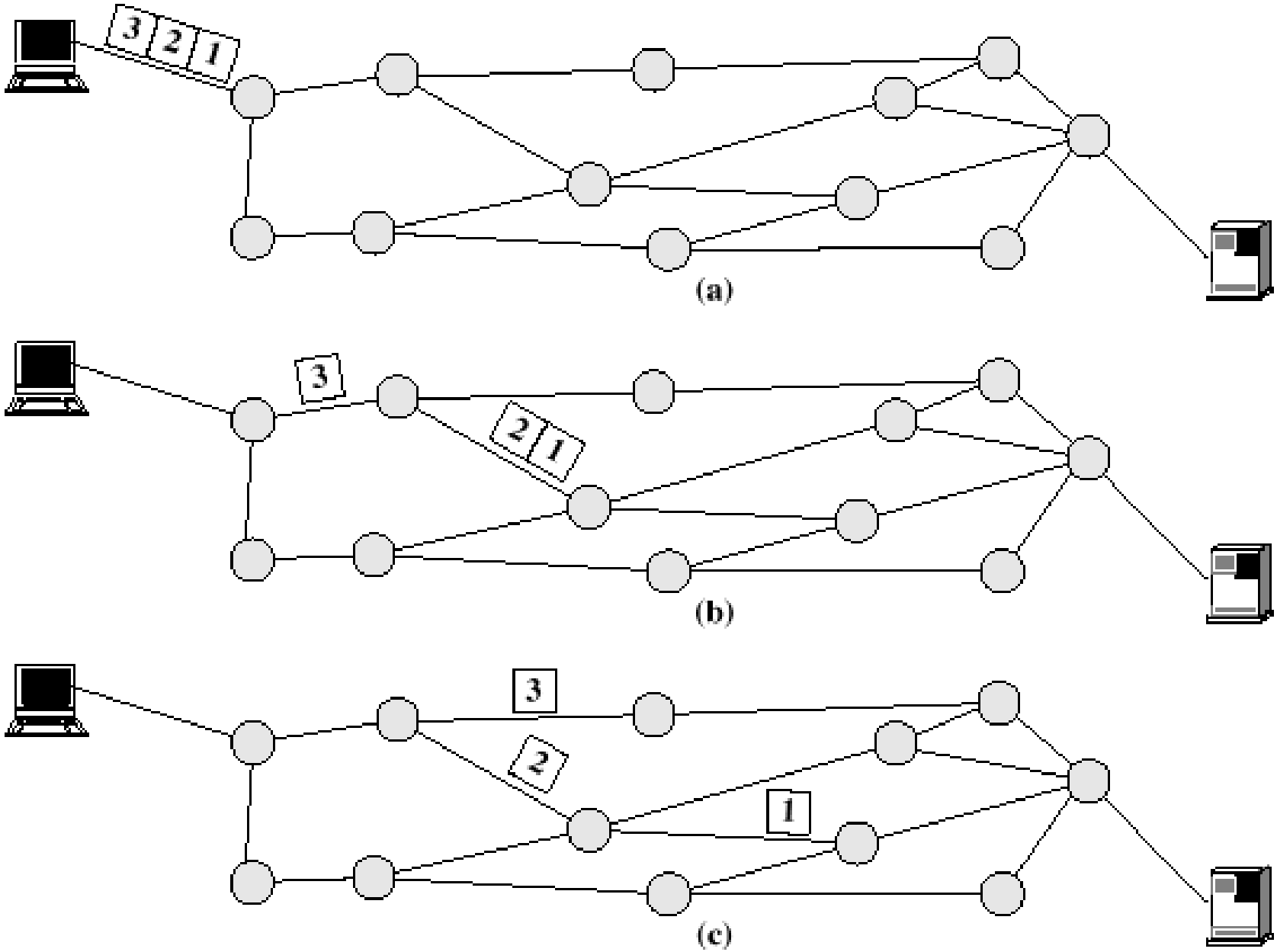
How Packet Switching Works

- Data is transmitted in blocks, called packets
- Before sending, the message is broken into a series of packets
  - Typical packet length is 1000 octets (bytes)
  - Packets consists of a portion of data plus a packet header that includes control information
- At each node en route, packet is received, stored briefly and passed to the next node

[Stallings., 2005]



[Stallings., 2005]

Figure 3.7 Packet Switching: Datagram Approach

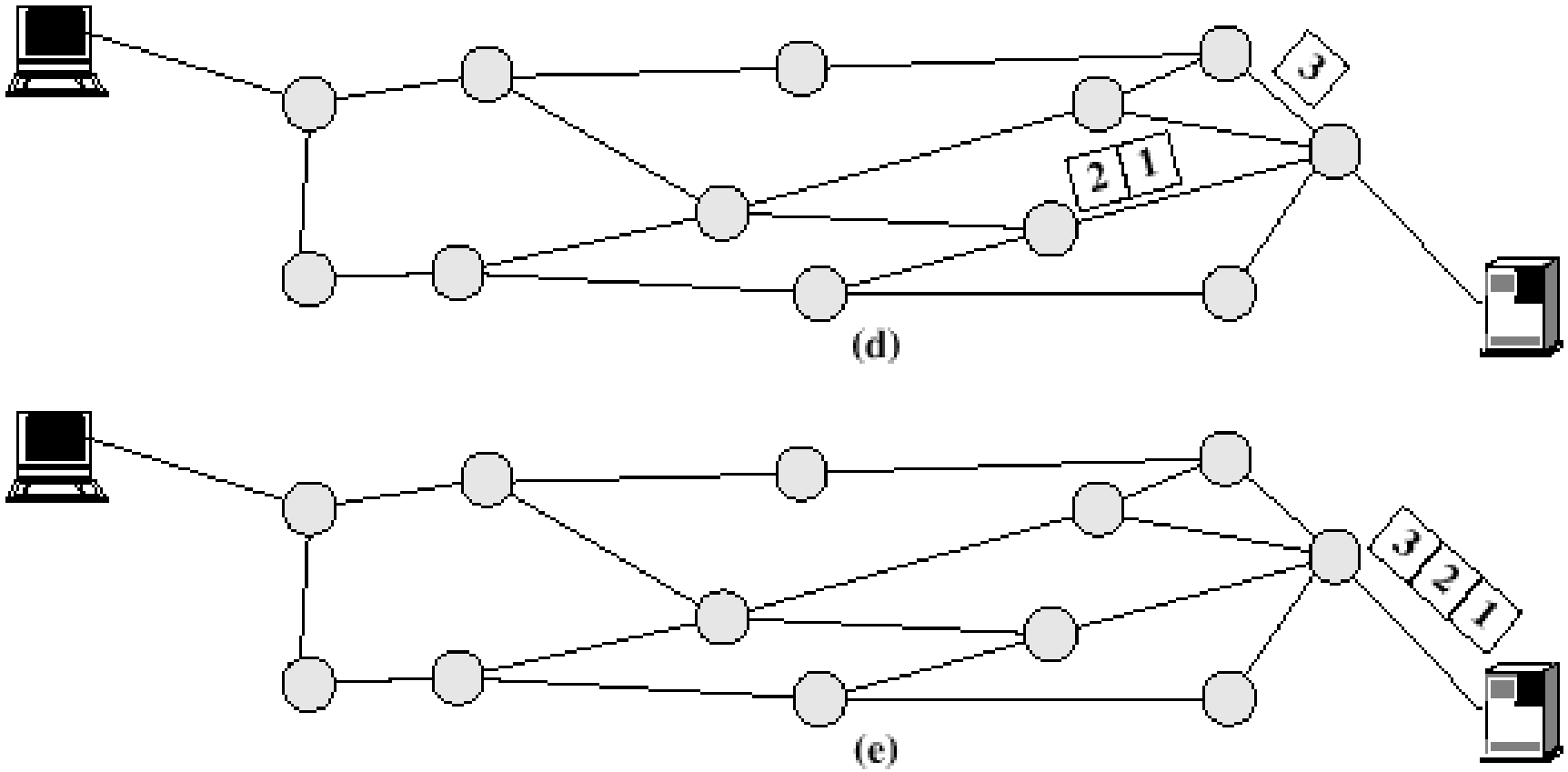


Figure 3.7 Packet Switching: Datagram Approach

[Stallings., 2005]

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Packet Switching Advantages

- 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

[Stallings., 2005]

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Disadvantages of Packet Switching

- 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

[Stallings., 2005]

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Packet Switching Networks - 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

[Stallings., 2005]

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Packet Switching Networks – Datagram

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

[Stallings., 2005]

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Packet Switching Networks – 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

[Stallings., 2005]

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Packet Switching Networks – Virtual Circuit

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

[Stallings., 2005]

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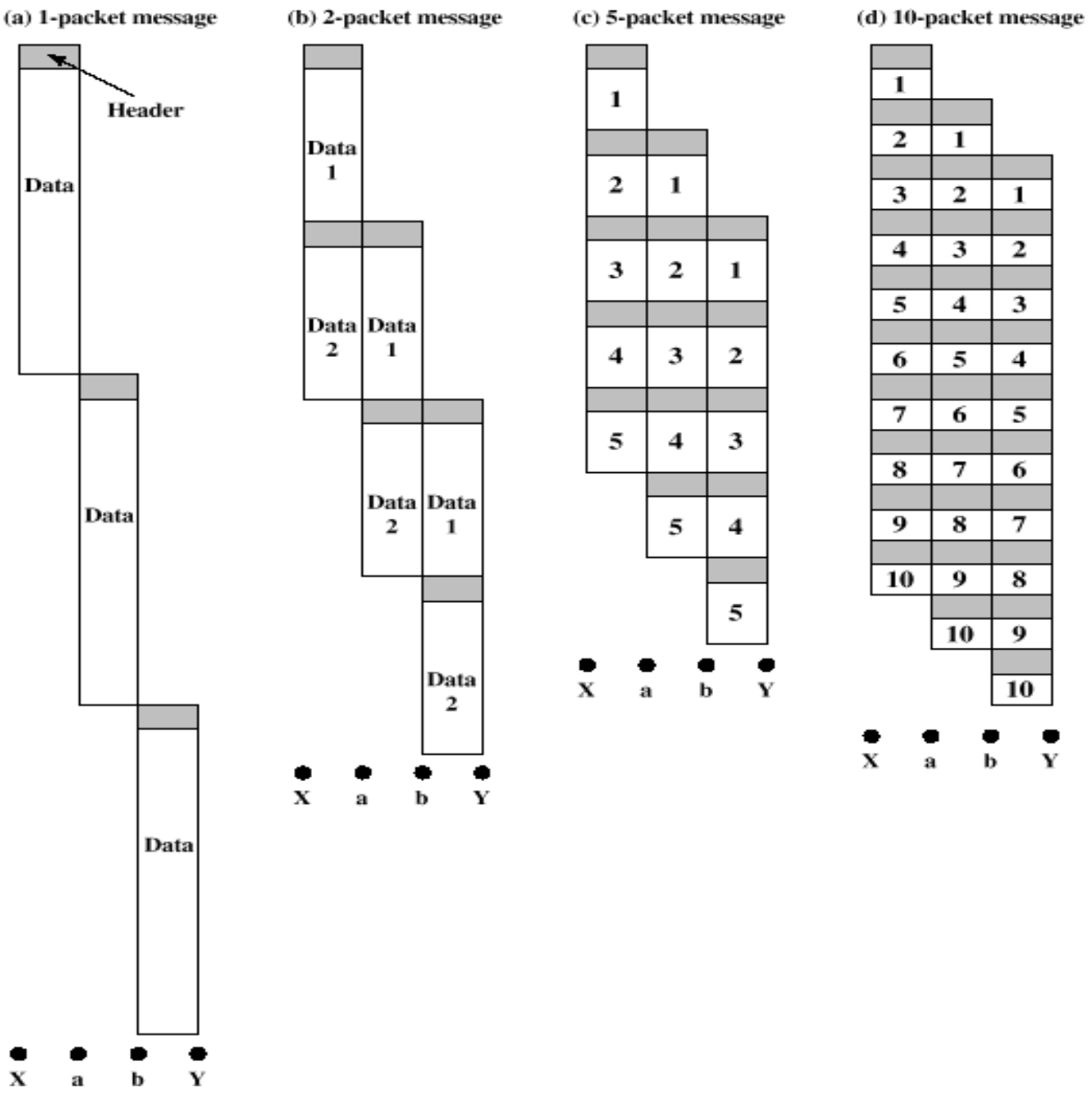

[Stallings., 2005]

Figure 3.9 Effect of Packet Size on Transmission Time

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Effect of Packet Size on Transmission

- Breaking up packets decreases transmission time because transmission is allowed to overlap
- Figure 3.9a
  - Entire message (40 octets) + header information (3 octets) sent at once
  - Transmission time: 129 octet-times
- Figure 3.9b
  - Message broken into 2 packets (20 octets) + header (3 octets)
  - Transmission time: 92 octet-times

[Stallings., 2005]

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Effect of Packet Size on Transmission

- Figure 3.9c
  - Message broken into 5 packets (8 octets) + header (3 octets)
  - Transmission time: 77 octet-times
- Figure 3.9d
  - Making the packets too small, transmission time starts increases
  - Each packet requires a fixed header; the more packets, the more headers

[Stallings., 2005]

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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

[Stallings., 2005]

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Agents Involved in Communication

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

[Stallings., 2005]

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TCP/IP Layers

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

[Stallings., 2005]

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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

[Stallings., 2005]

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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

[Stallings., 2005]

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T: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

[Stallings., 2005]

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TCP/IP Host-to-Host, or Transport Layer

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

[Stallings., 2005]

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TCP/IP Application Layer

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

[Stallings., 2005]

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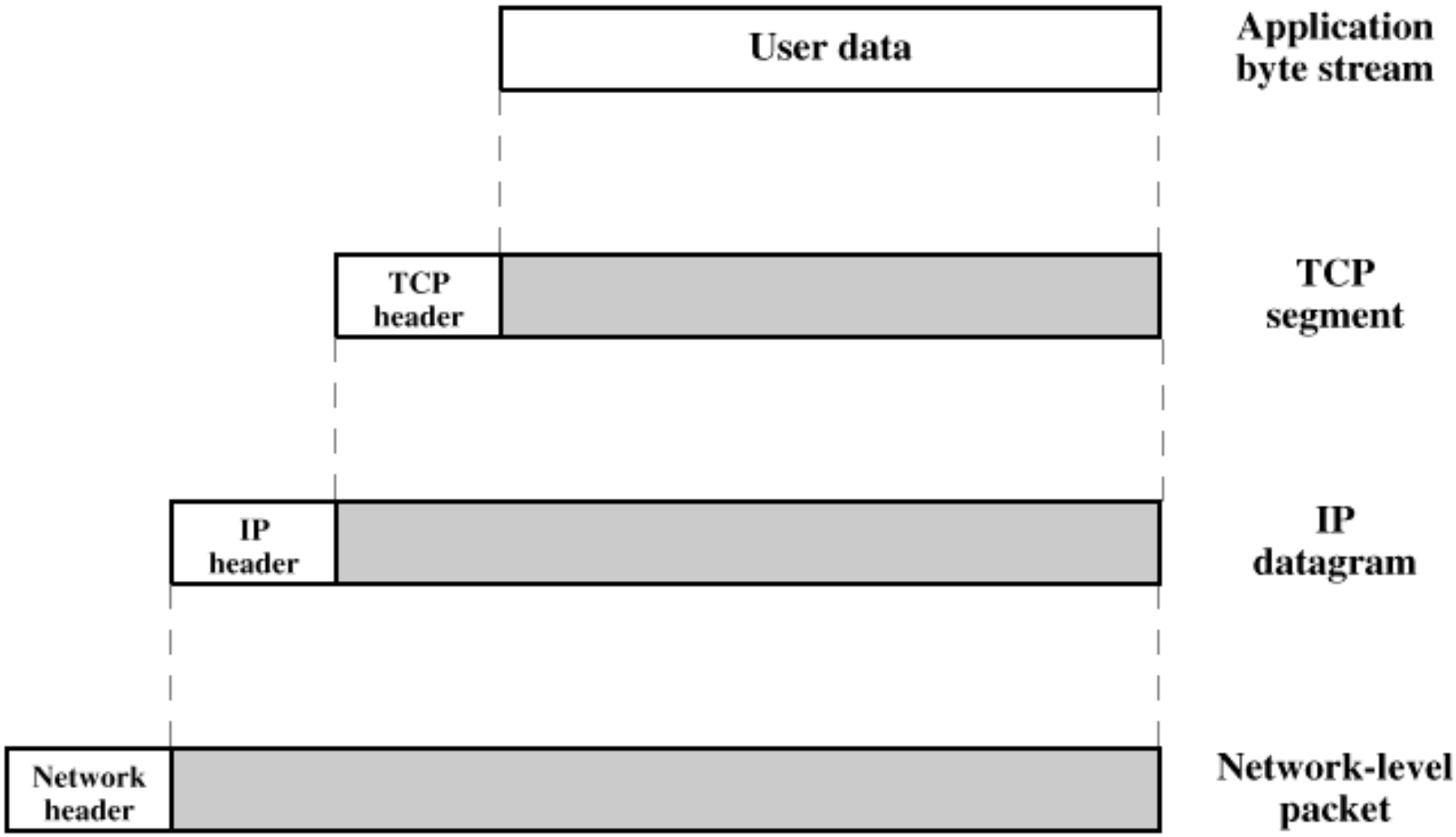
Protocol Data Units (PDUs)



[Stallings., 2005]

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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
- TELNET
  - Provides a remote logon capability

[Stallings., 2005]

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Layers of the OSI Model

- Application
- Presentation
- Session
- Transport
- Network
- Data link
- Physical

[Stallings., 2005]

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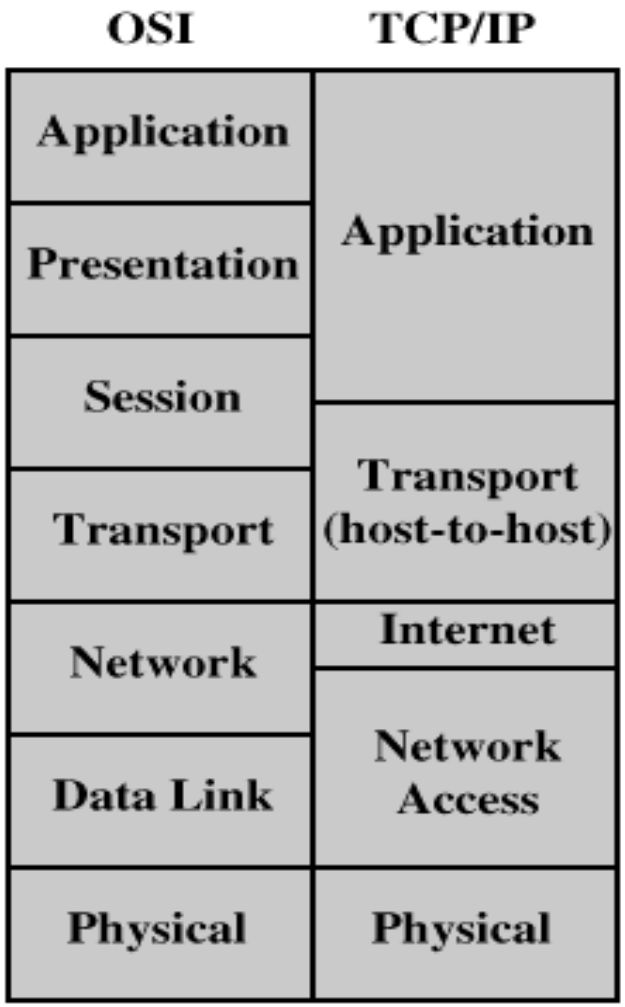
Comparison of OSI and TCP/IP



[Stallings., 2005]

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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

[Stallings., 2005]

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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)

[Stallings., 2005]

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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

[Stallings., 2005]

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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

[Stallings., 2005]

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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

[Stallings., 2005]

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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

[Stallings., 2005]