Local Area Network Overview

Chapter 11 in Stallings 10th Edition

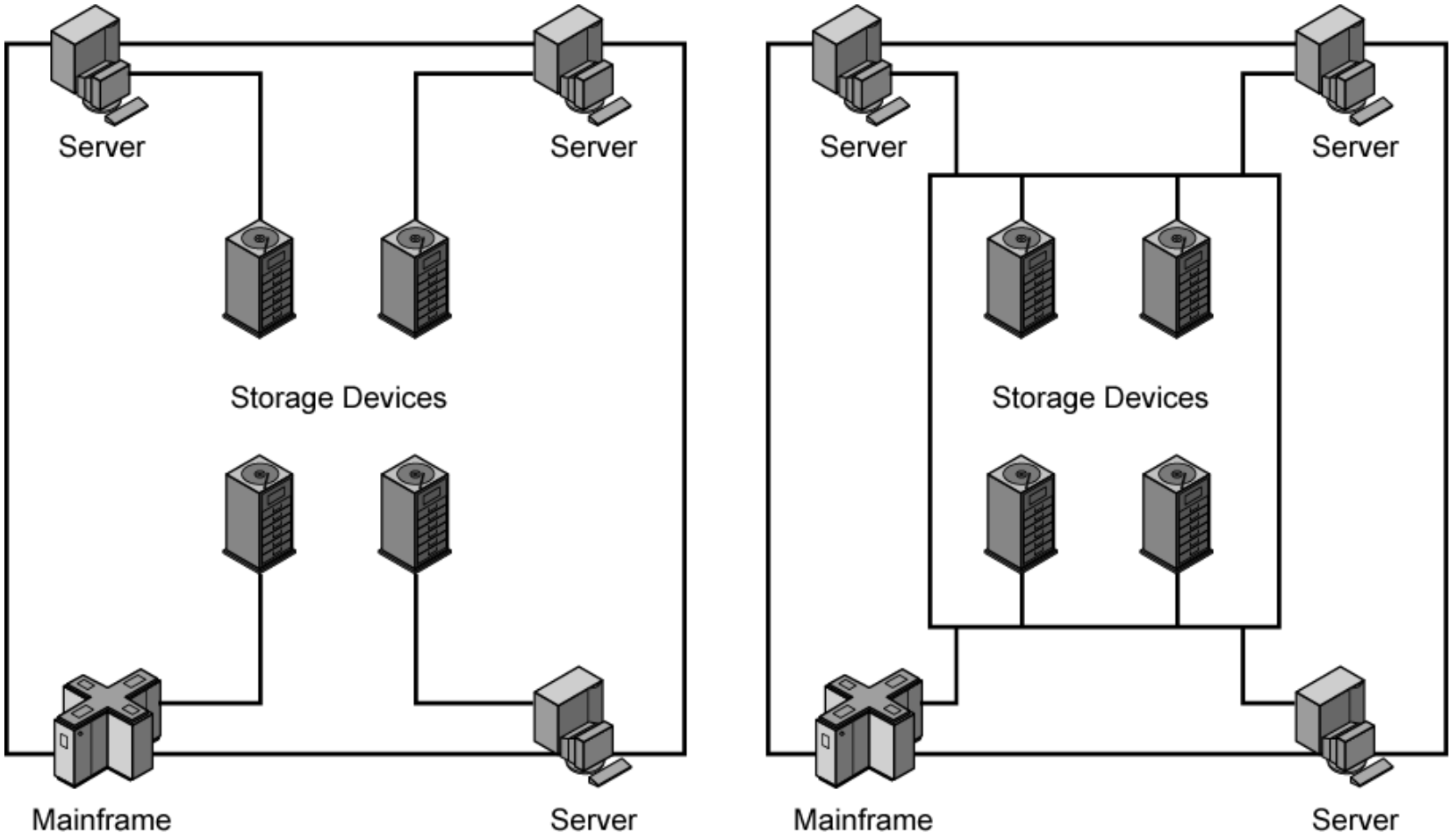
LAN Applications (1)

- Personal computer LANs
  - —Low cost
  - —Limited data rate
- Back end networks
  - —Interconnecting large systems (mainframes and large storage devices)
    - High data rate
    - High speed interface
    - Distributed access
    - Limited distance
    - Limited number of devices

LAN Applications (2)

- Storage Area Networks
  - Separate network handling storage needs
  - Detaches storage tasks from specific servers
  - Shared storage facility across high-speed network
  - Hard disks, tape libraries, CD arrays
  - Improved client-server storage access
  - Direct storage to storage communication for backup
- High speed office networks
  - Desktop image processing
  - High capacity local storage
- Backbone LANs
  - Interconnect low speed local LANs
  - Reliability
  - Capacity
  - Cost

Storage Area Networks



(a) Server-based storage

(b) Storage area network

LAN Architecture

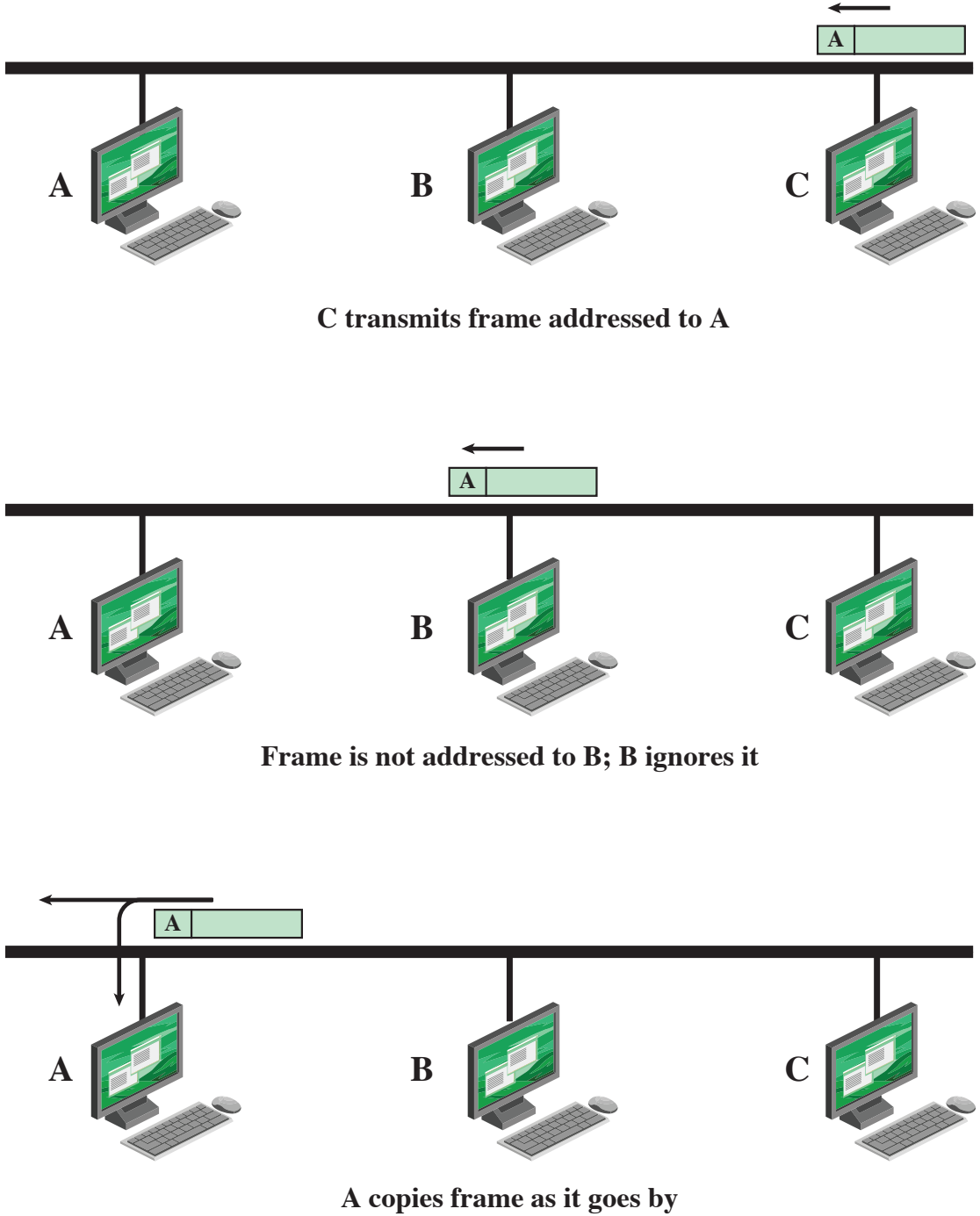
- Topologies
- Transmission medium
- Layout
- Medium access control

Bus

- Multipoint medium
- Transmission propagates throughout medium
- Heard by all stations
  - Need to identify target station
    - Each station has unique address
- Full duplex connection between station and tap
  - Allows for transmission and reception
- Need to regulate transmission
  - To avoid collisions
  - To avoid hogging
    - Data in small blocks - frames
- Terminator absorbs frames at end of medium

Frame Transmission on Bus LAN

Figure 11.1

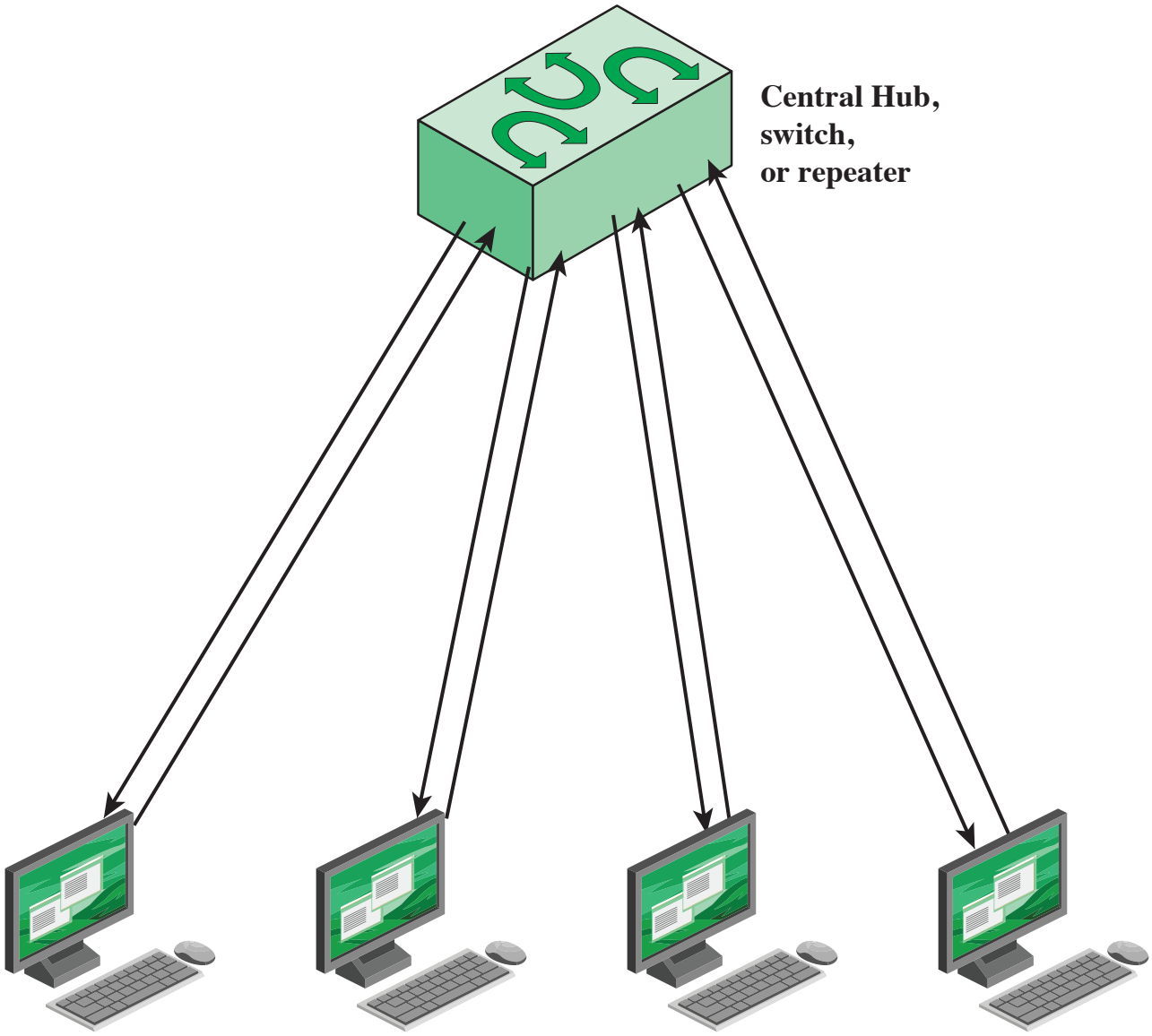


Star Topology

- Each station connected directly to common central node
  - —Usually via two point to point links
- Central node can broadcast
  - —Physical star, logical bus
  - —Only one station can transmit at a time (hub)
- Central node can act as frame switch

Star Topology

Figure 11.2

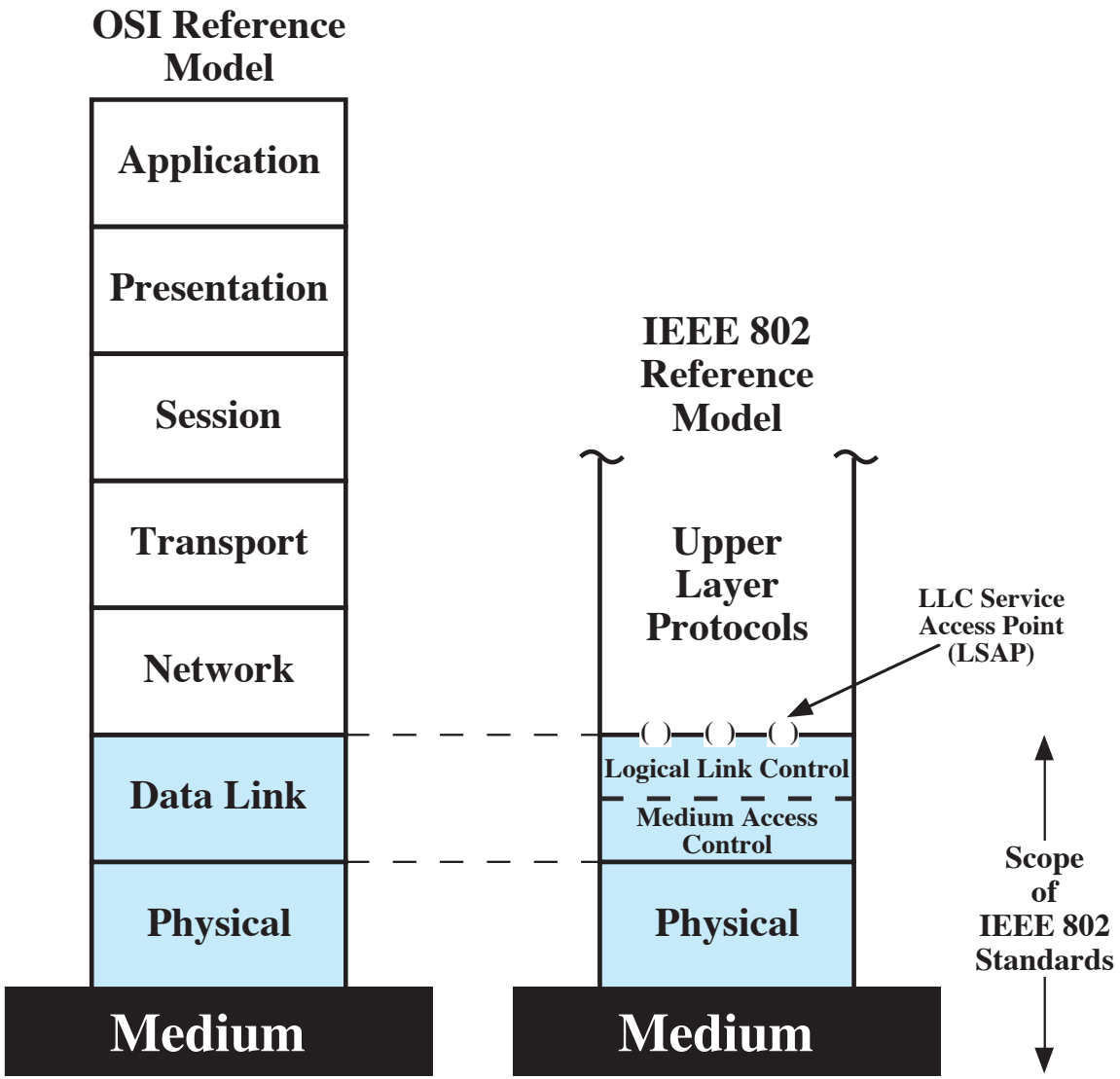


Protocol Architecture

- Lower layers of OSI model
- IEEE 802 reference model
- Physical
- Logical link control (LLC)
- Media access control (MAC)

IEEE 802 vs OSI

Figure 1



802 Layers - Physical

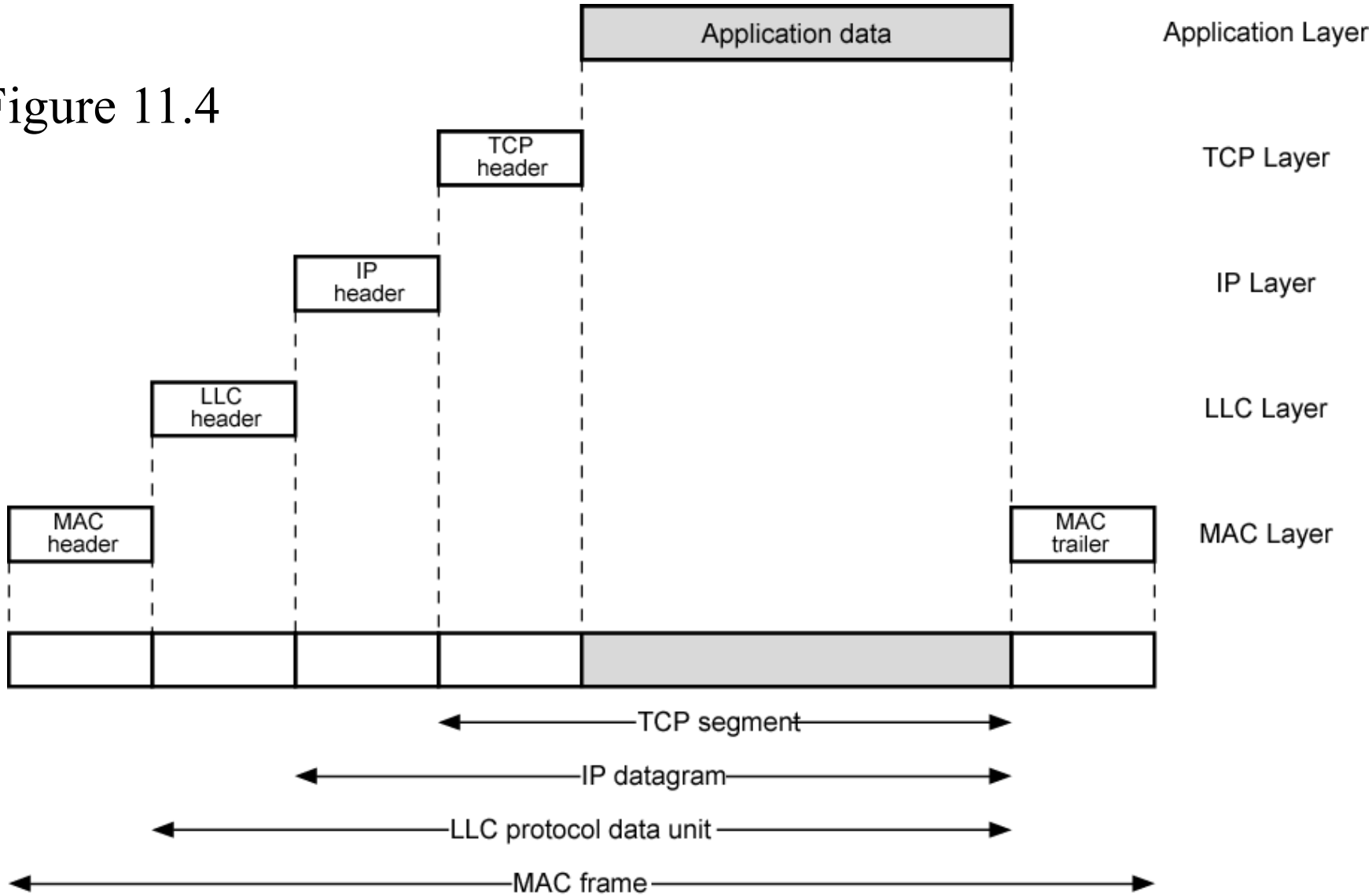
- Encoding/decoding
- Preamble generation/removal
- Bit transmission/reception
- Transmission medium and topology

IEEE 802 Layers

- **Logical Link Control Layer (LLC)**
  - Provide interface to higher levels
  - Perform flow and error control
- **Media Access Control (MAC)**
  - On transmit assemble data into frame
  - On reception disassemble frame, perform address recognition and error detection
  - Govern access to LAN transmission medium

LAN Protocols in Context

Figure 11.4



Logical Link Control

- Transmission of link level PDUs between stations
- Must support multi-access, shared medium
- Relieved of some details of link access by the MAC layer
- Addressing involves specifying source and destination LLC users
  - Referred to as service access points (SAPs)

LLC Services

Unacknowledged connectionless service

- Data-gram style service
- Delivery of data is not guaranteed

Connection-mode service

- Logical connection is set up between two users
- Flow and error control are provided

Acknowledged connectionless service

- Datagrams are to be acknowledged, but no logical connection is set up

LLC Service Alternatives

Unacknowledged connectionless service

- Requires minimum logic
- Avoids duplication of mechanisms
- Preferred option in most cases

Connection-mode service

- Used in simple devices
- Provides flow control and reliability mechanisms

Acknowledged connectionless service

- Large communication channel needed
- Time critical or emergency control signals

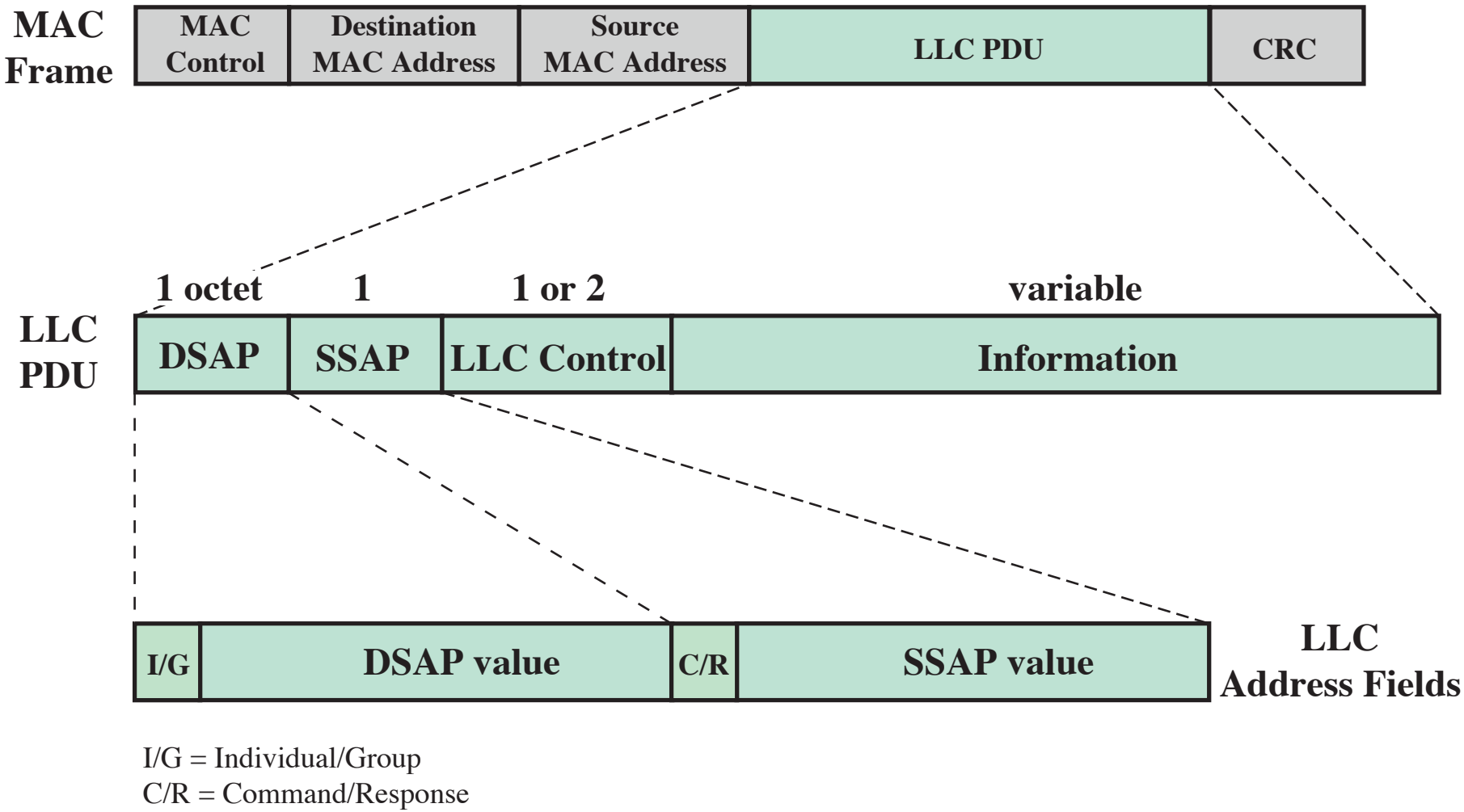


Figure 11.5 LLC PDU in a Generic MAC Frame Format

LLC Protocol

- Modeled after HDLC
- Asynchronous balanced mode
  - Connection mode (type 2) LLC service
- Unacknowledged connectionless service
  - Using unnumbered information PDUs (type 1)
- Acknowledged connectionless service
  - Using 2 new unnumbered PDUs (type 3)
- Permits multiplexing using LSAPs

Media Access Control

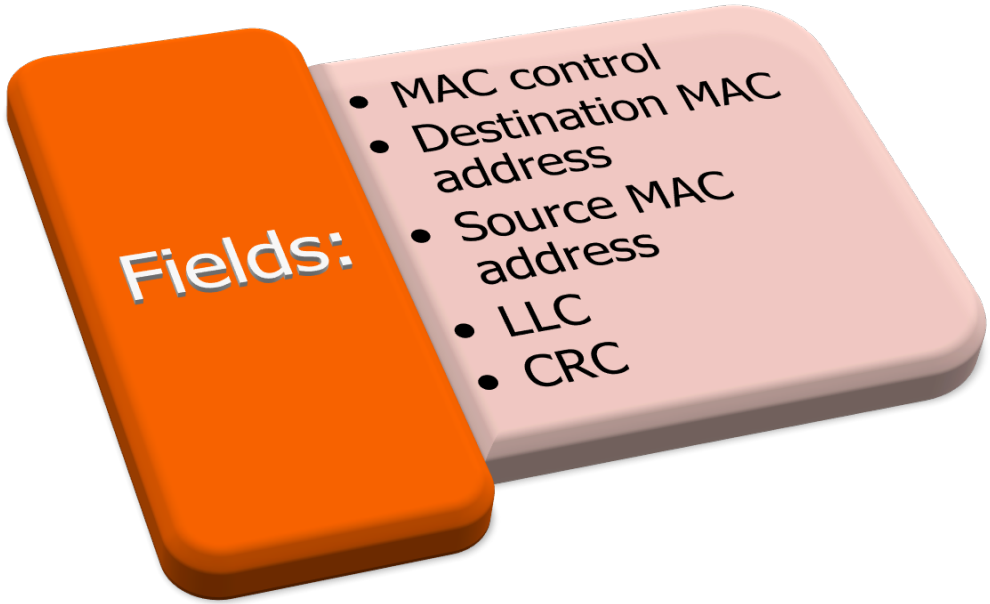
- Where
  - —Central
    - Greater control
    - Simple access logic at station
    - Avoids problems of co-ordination
    - Single point of failure
    - Potential bottleneck
  - —Distributed
- How
  - —Synchronous
    - Specific capacity dedicated to connection, not optimal
  - —Asynchronous
    - In response to demand, round robin, reservation, contention

Asynchronous Systems

- Round robin
  - Good if many stations have data to transmit over extended period
- Reservation
  - Divide medium into slots.
  - Good for stream traffic
- Contention
  - Good for bursty traffic
  - All stations contend for time
  - Distributed
  - Simple to implement
  - Efficient under moderate load
  - Tend to collapse under heavy load

MAC Frame Handling

- MAC layer receives data from LLC layer
- PDU is referred to as a MAC frame
- MAC layer detects errors and discards frames
- LLC optionally retransmits unsuccessful frames



Bridges

- Connects similar LANs with identical physical and link layer protocols
- Minimal processing
- Can map between MAC formats
- Reasons for use:
  - Reliability
  - Performance
  - Security
  - Geography

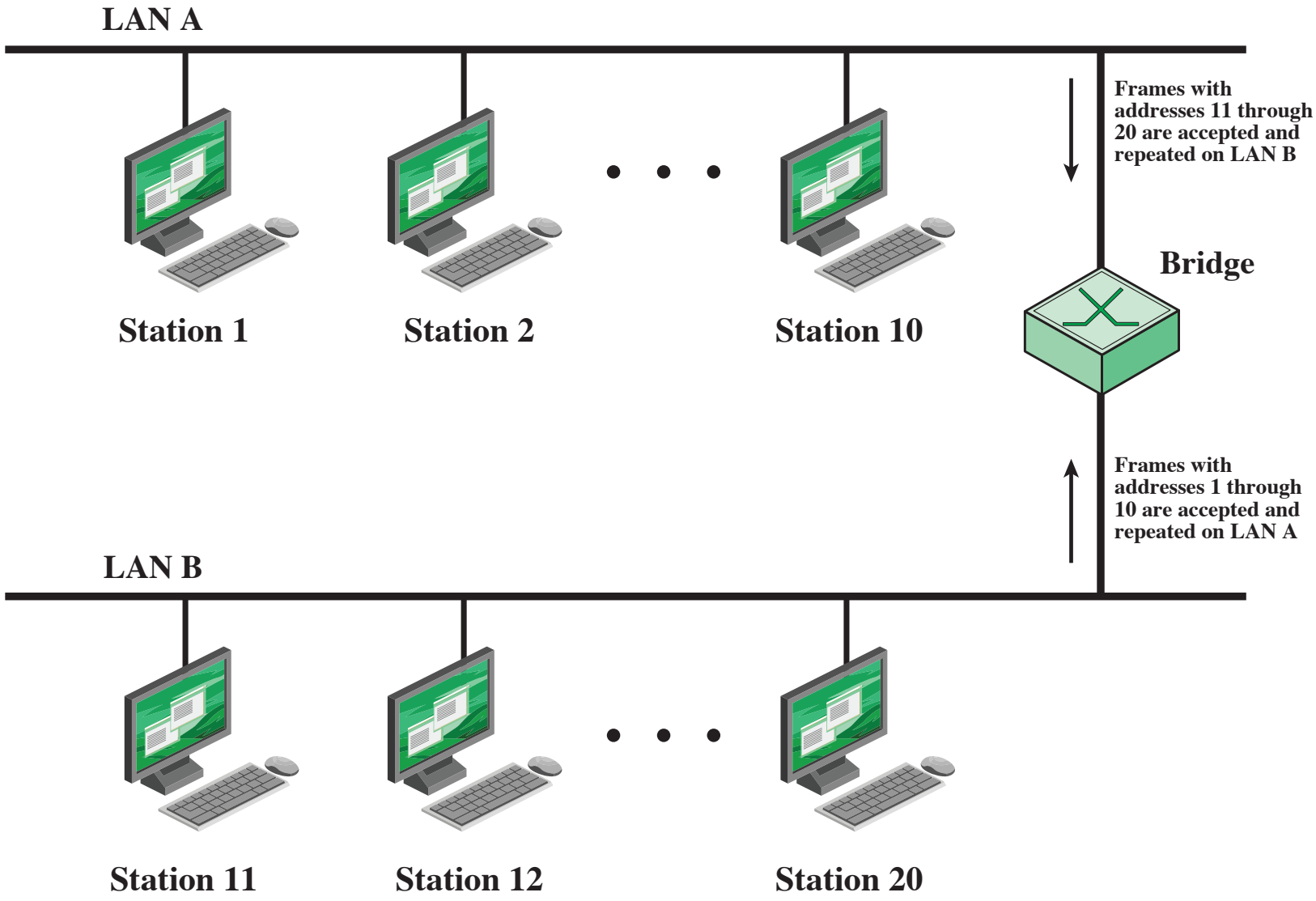
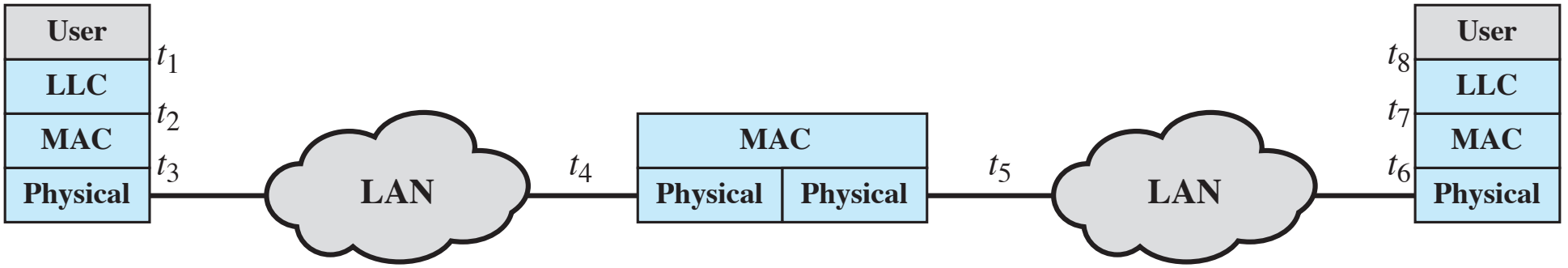


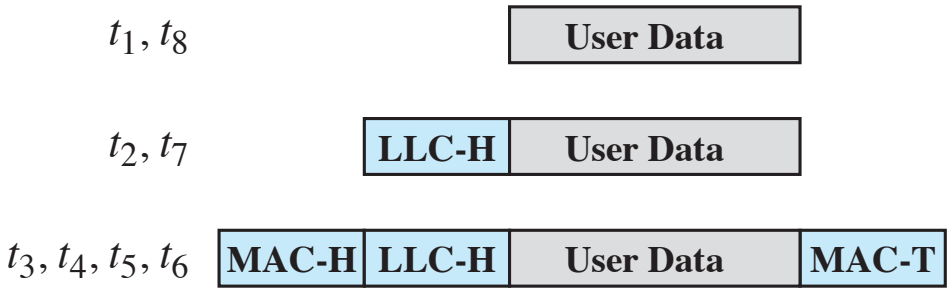
Figure 11.6 Bridge Operation

Bridge Design Aspects

- Makes no modification to the content or format of the frames it receives
- Should contain enough buffer space to meet peak demands
- Must contain routing and addressing intelligence
- May connect more than two LANs
- Bridging is transparent to stations



(a) Architecture



(b) Operation

Figure 11.7 Connection of Two LANs by a Bridge

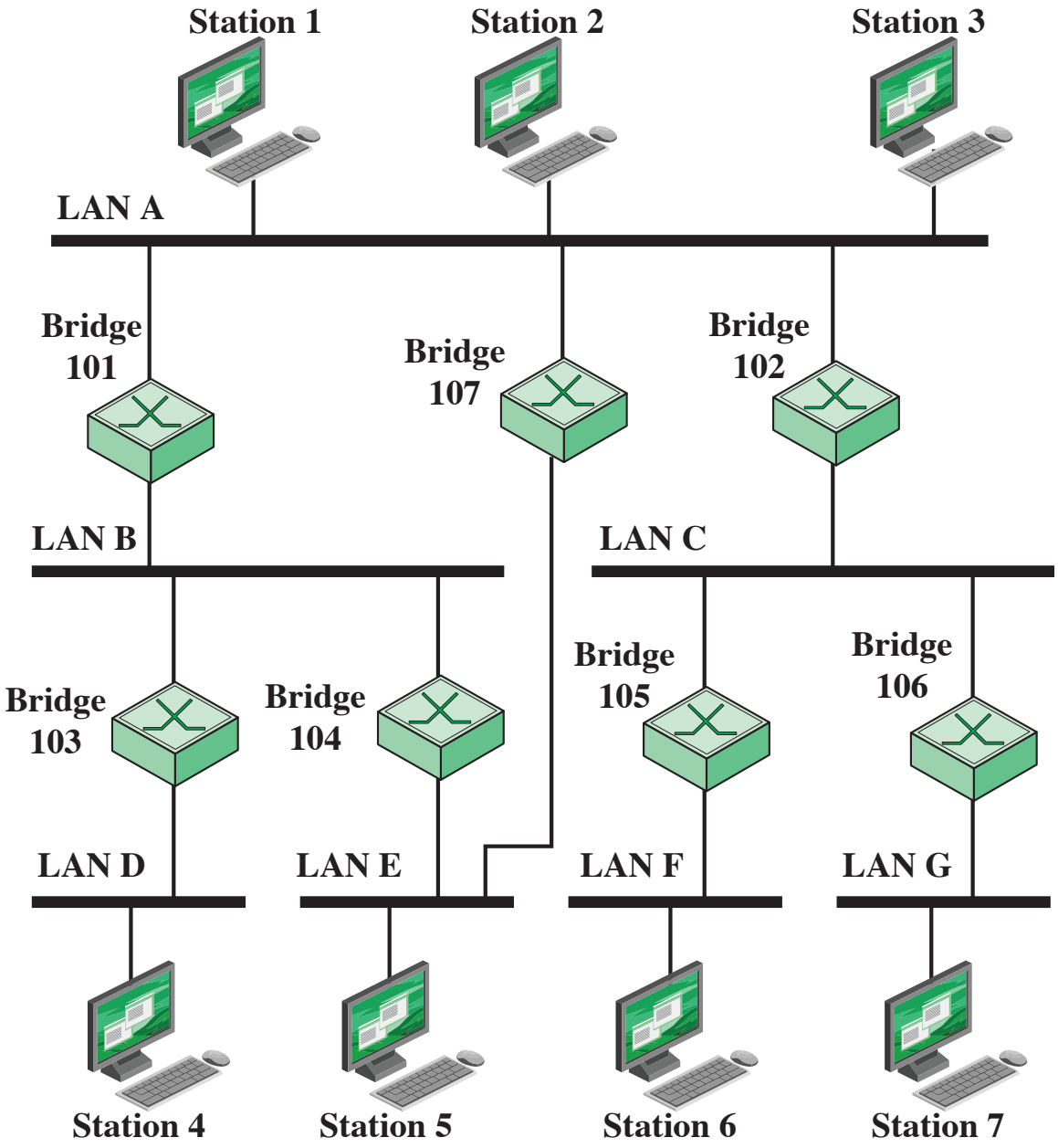


Figure 11.8 Configuration of Bridges and LANs, with Alternate Routes

Fixed Routing

- Simplest and most common strategy
- Suitable for small internets and internets that are relatively stable
- A fixed route is selected for each pair of LANs
  - Usually least hop route
- Only change when topoloy changes
- Widely used but limited flexibility

Spanning Tree

- Bridge automatically develops routing table
- Automatically update in response to changes
- Algorithm consists of 3 mechanisms:
  - —Frame forwarding
  - —Address learning
  - —Loop resolution

Frame forwarding

- Maintain forwarding database for each port
  - —List station addresses reached through each port
- For a frame arriving on port X:
  - —Search forwarding database to see if MAC address is listed for any port (except port X)
  - —If address not found, forward to all ports (except X)
  - —If address listed for some port Y, check port Y for blocking or forwarding state
    - Blocking prevents port from receiving or transmitting
  - —If Y is not blocked, transmit frame through port Y

Address Learning

- Can preload forwarding database
- When frame arrives at port X, it has come from the LAN attached to port X
- Use source address to update forwarding database for port X to include that address
- Have a timer on each entry in database
  - —If timer expires, entry is removed
- Each time frame arrives, source address checked against forwarding database
  - —If present timer is reset and direction recorded
  - —If not present entry is created and timer set

Spanning Tree Algorithm

- Address learning works for tree layout if there are no alternate routes in the network
  - —Alternate route means there is a closed loop
- For any connected graph there is a spanning tree maintaining connectivity with no closed loops
- Algorithm must be dynamic

IEEE 802.1 Spanning Tree Algorithm:

- Each bridge assigned unique identifier
- Cost assigned to each bridge port
- Exchange information between bridges to find spanning tree
- Automatically updated whenever topology changes

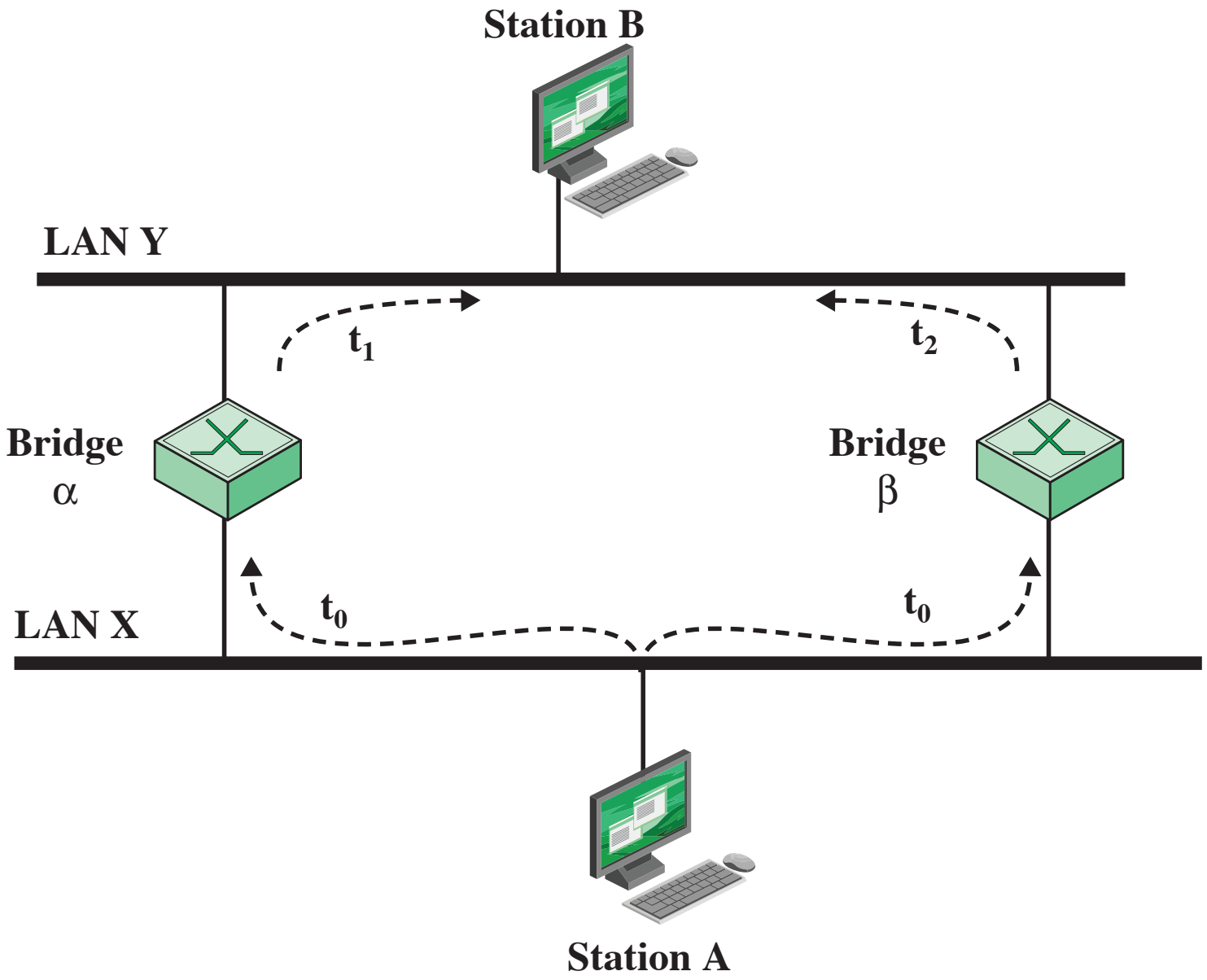


Figure 11.9 Loop of Bridges

Hubs

- Active central element of star layout
- Each station connected to hub by two lines
- Hub acts as a repeater
- Length of a line is limited to about 100m
- Optical fiber may be used to about 500m
- Physically a star, logically a bus
- Transmission from any one station is received by all other stations
- If two stations transmit at the same time there will be a collision

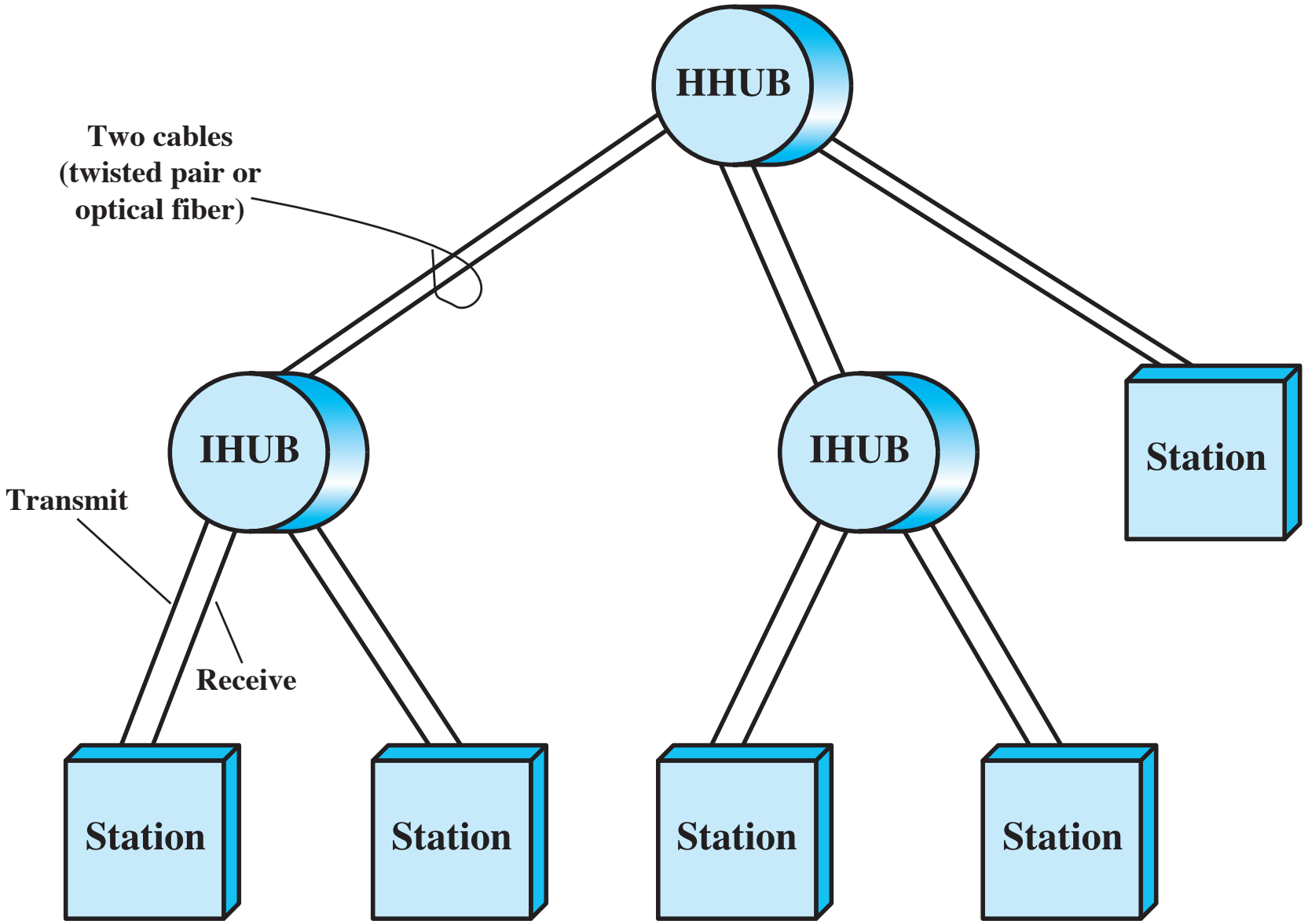


Figure 11.10 Two-Level Star Topology

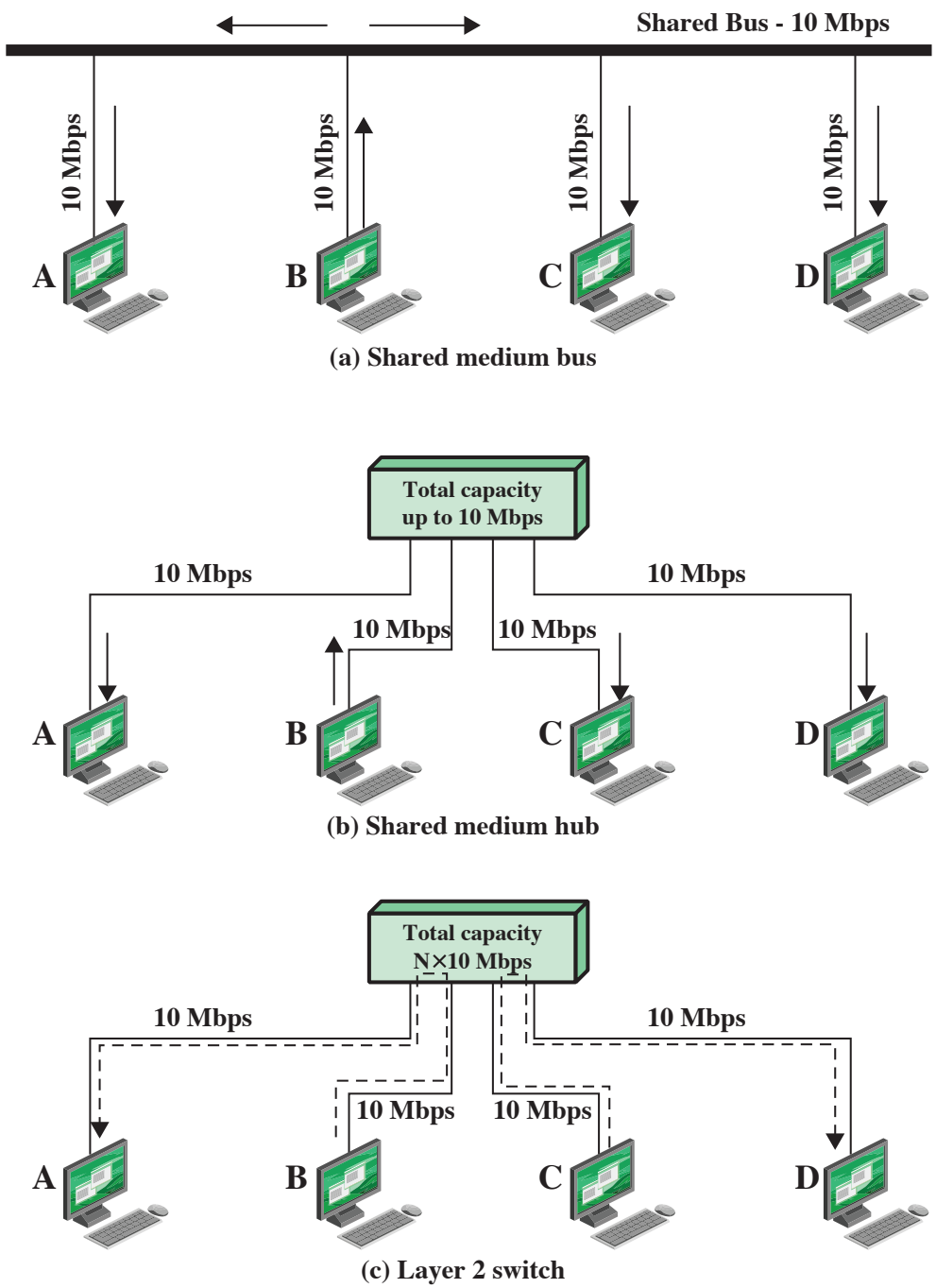


Figure 15.11 LAN Hubs and Switches

Layer 2 Switch Benefits

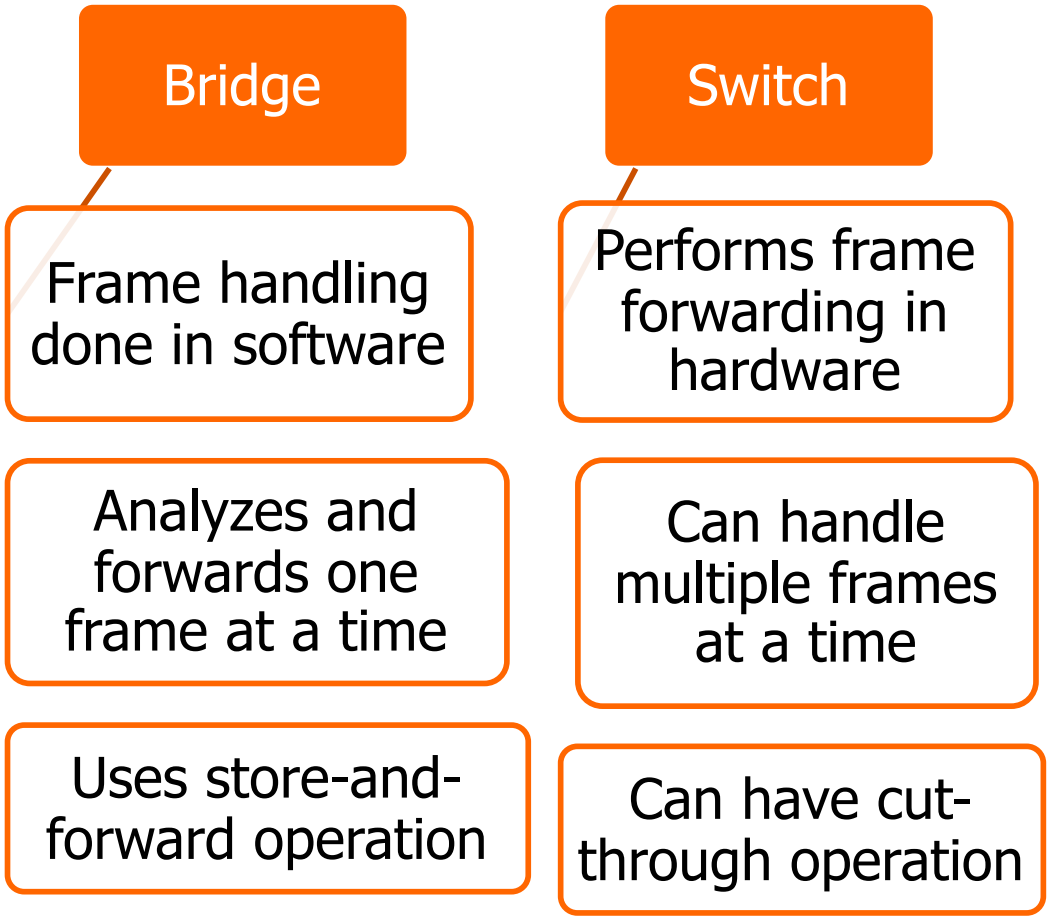
- No change is required to the software or hardware of the attached devices to convert a bus LAN or a hub LAN to a switched LAN
- Have dedicated capacity equal to original LAN
  - Assuming switch has sufficient capacity to keep up with all devices
- Scales easily
  - Additional devices attached to switch by increasing capacity of layer 2

Types of Layer 2 Switch

- Store-and-forward switch
  - Accepts frame on input line
  - Buffers it briefly,
  - Then routes it to appropriate output line
  - Delay between sender and receiver
  - Boosts integrity of network
- Cut-through switch
  - Takes advantage of destination address appearing at beginning of frame
  - Switch begins repeating frame onto output line as soon as it recognizes destination address
  - Highest possible throughput
  - Risk of propagating bad frames
    - Switch unable to check CRC prior to retransmission

Layer 2 Switch vs. Bridge

- Differences between switches and bridges:



- Layer 2 switch can be viewed as full-duplex hub
- Incorporates logic to function as multiport bridge
- New installations typically include layer 2 switches with bridge functionality rather than bridges

One big LAN

No separation for broadcasts

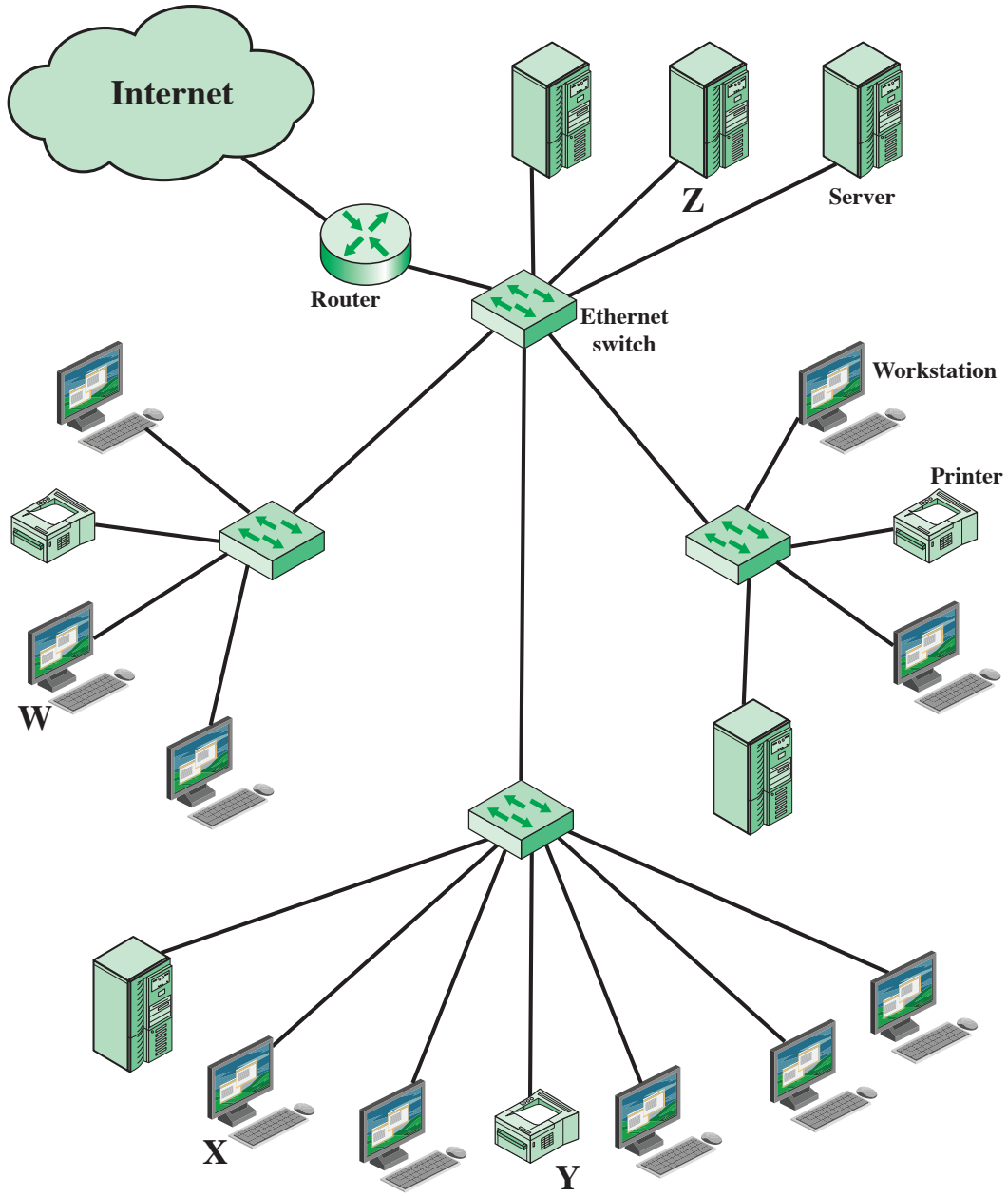


Figure 11.12 A LAN Configuration

Router V:
Now 4 separate LANS

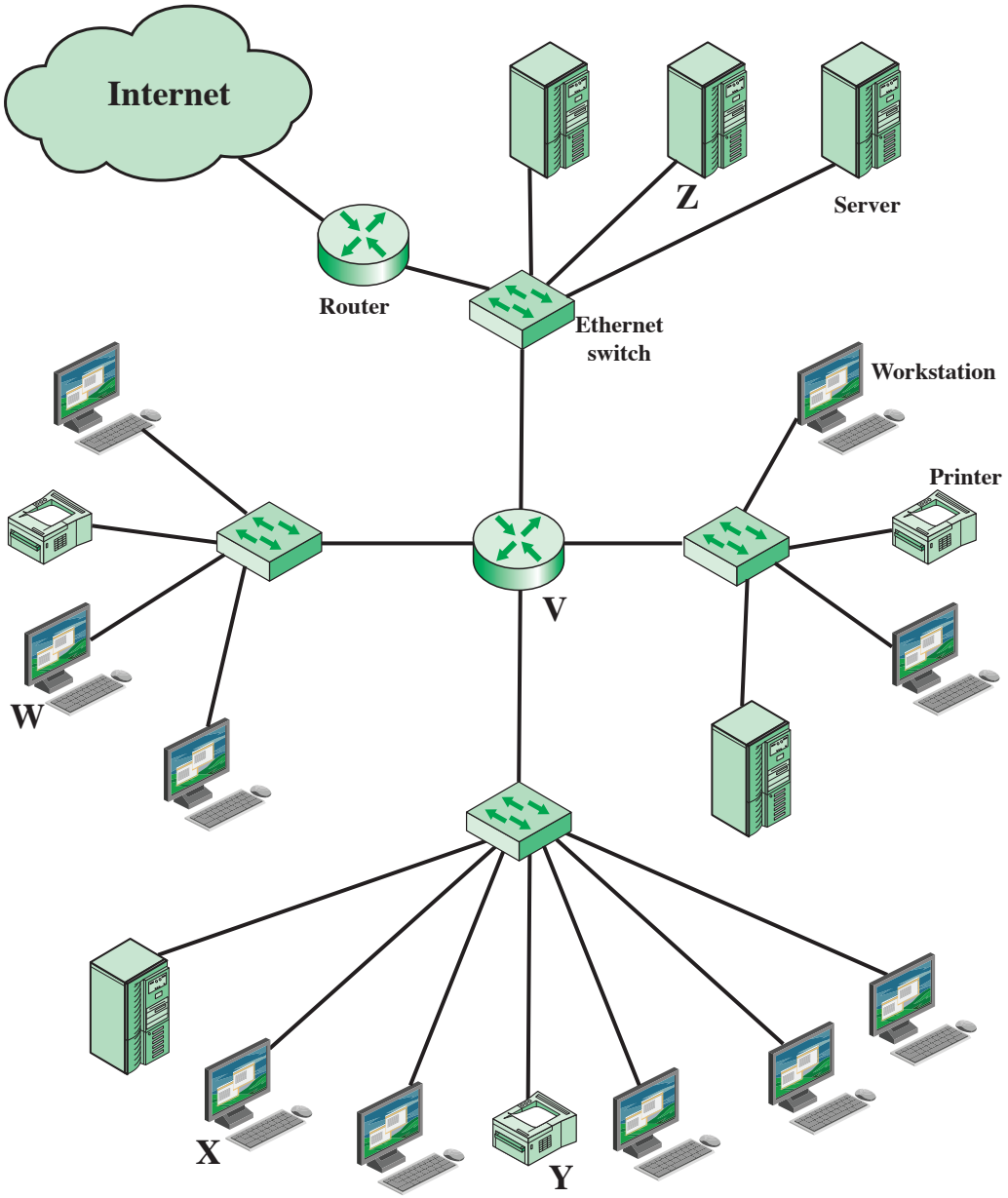


Figure 11.13 A Partitioned LAN

Problems with Routers

- Routers do all IP-level processing in software
  - —High-speed LANs and high-performance layer 2 switches pump huge # of packets per second
  - —Software-based router are slower
- Solution: layer 3 switches
  - —Implement packet-forwarding logic of router in hardware
- Two categories
  - —Packet by packet
  - —Flow based

VLAN:
(Virtual LAN)

Logical subgroup
within LAN

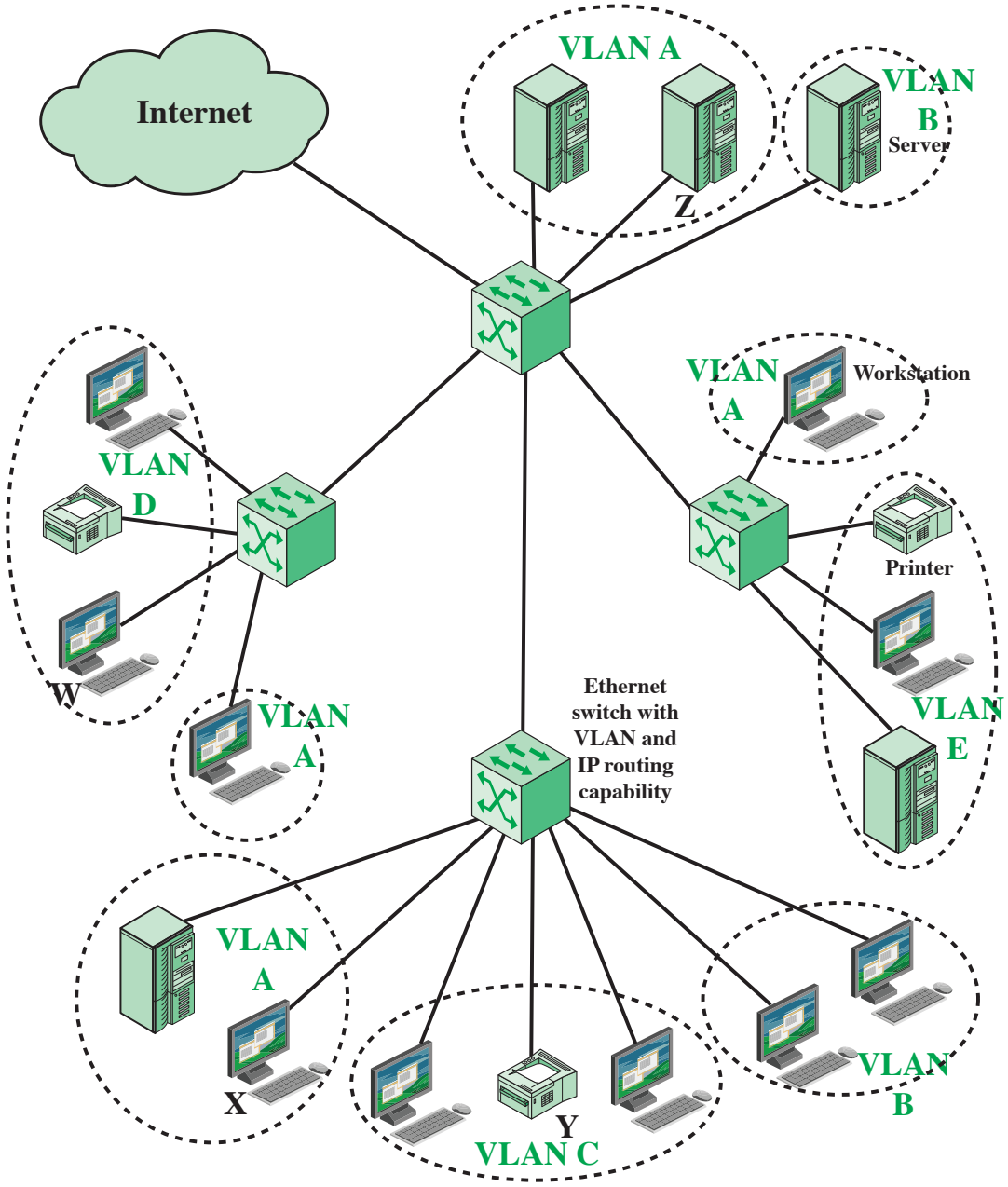


Figure 11.14 A VLAN Configuration

Defining VLANs

- Broadcast domain consisting of a group of end stations not limited by physical location and communicate as if they were on a common LAN
- Membership by:
  - Port group
  - MAC address
  - Protocol information

Communicating VLAN Membership

Switches need to know VLAN membership

- Configure information manually
- Network management signaling protocol
- Frame tagging (IEEE802.1Q)

Summary

- Bus and tree topologies and transmission media
  - Topologies
  - Choice of topology
  - Choice of transmission medium
- LAN protocol architecture
  - IEEE 802 reference model
  - Logical link control
  - Medium access control
- Hubs and switches
  - Hubs
  - Layer 2 switches
- Bridges
  - Functions of a bridge
  - Bridge protocol architecture
  - Fixed routing
  - The spanning tree approach
- Virtual LANs
  - The use of virtual LANs
  - Defining VLANs
  - Communicating VLAN membership