Data and Computer Communications

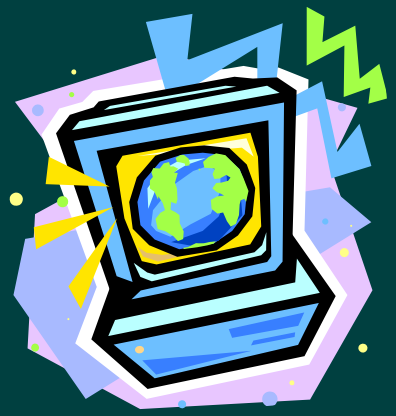
Tenth Edition

by William Stallings

CHAPTER 11

Local Area Network Overview

"There is some evidence that computer networks will have a large impact on society. Likely areas are the economy, resources, small computers, human-to-human interaction, and computer research."



—*What Can Be Automated?*
The Computer Science and Engineering Research Study,
MIT Press, 1980

Bus Topology

- Topology
  - Refers to the way in which the endpoints, or stations, attached to the network are interconnected
- Bus topology
  - All stations attach, through a tap, directly to a linear transmission medium, or bus
  - Full-duplex operation between the station and the tap allows data to be transmitted onto the bus and received from the bus
  - A transmission from any station propagates the length of the medium in both directions and can be received by all other stations
  - At each end of the bus is a terminator, which absorbs any signal, removing it from the bus

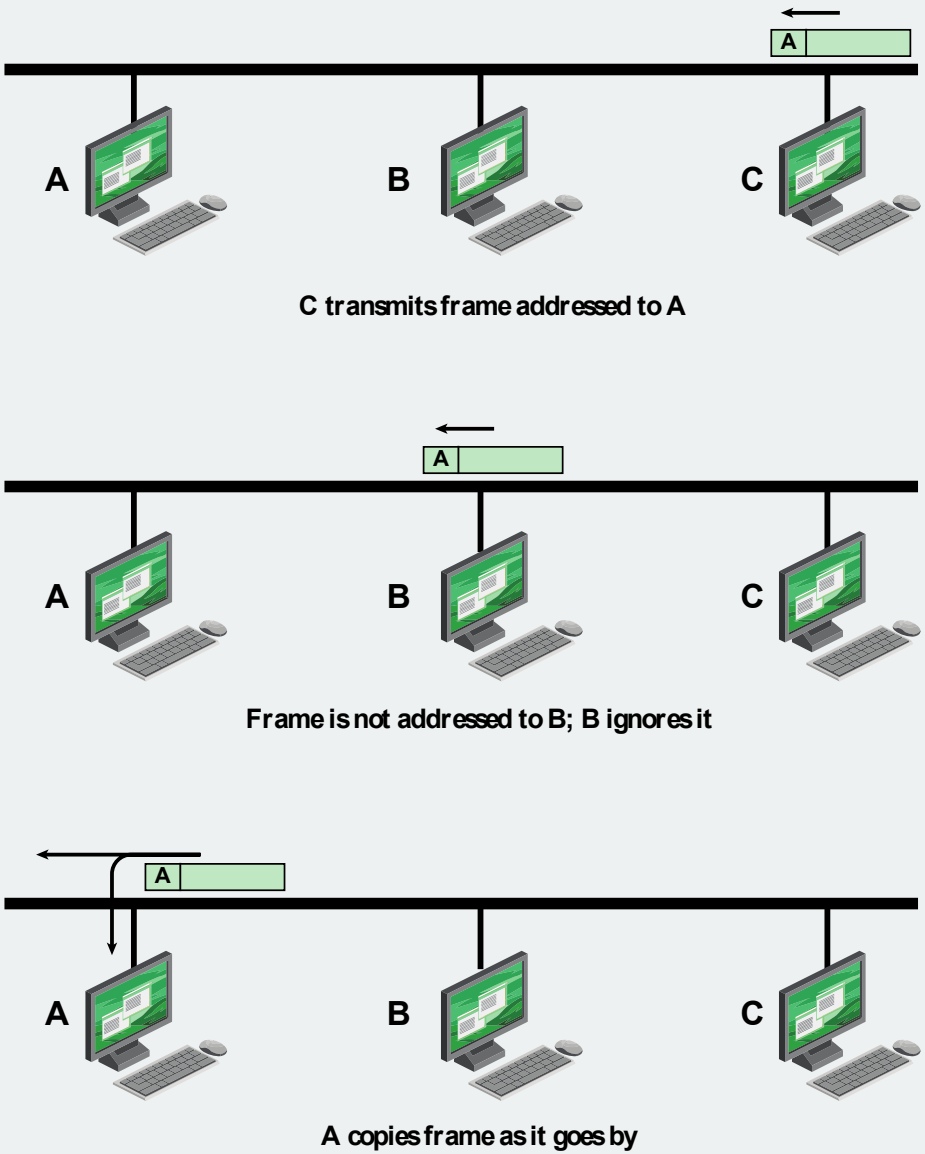


Figure 11.1 Frame Transmission on a Bus LAN

Star Topology

- Each station connects to common central node
  - Usually via two point-to-point links
    - One for transmission and one for reception

Central node

- Operate in broadcast fashion
- Physical star, logical bus
- Only one station can transmit at a time (hub)
- Can act as frame switch

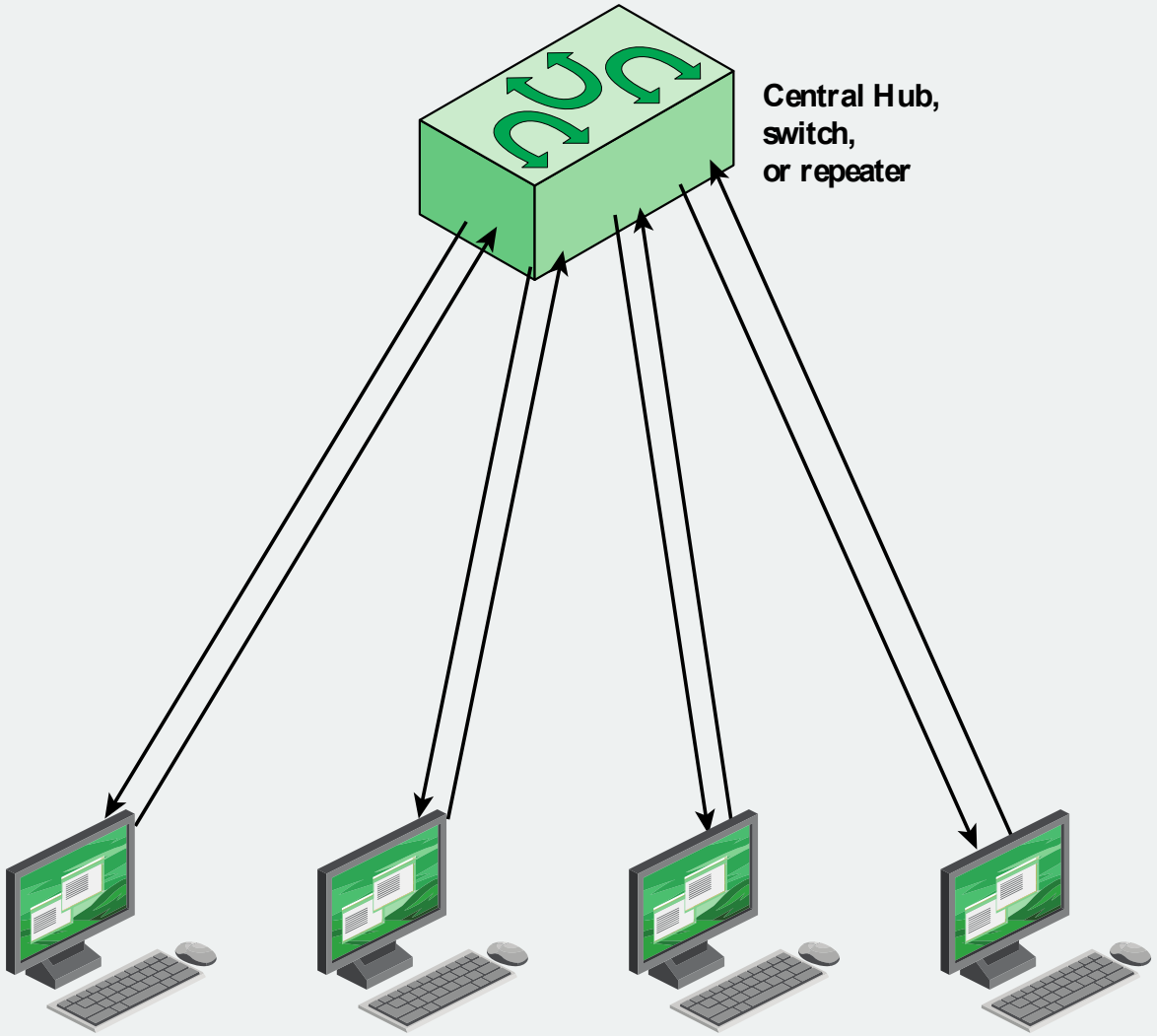


Figure 11.2 Star Topology

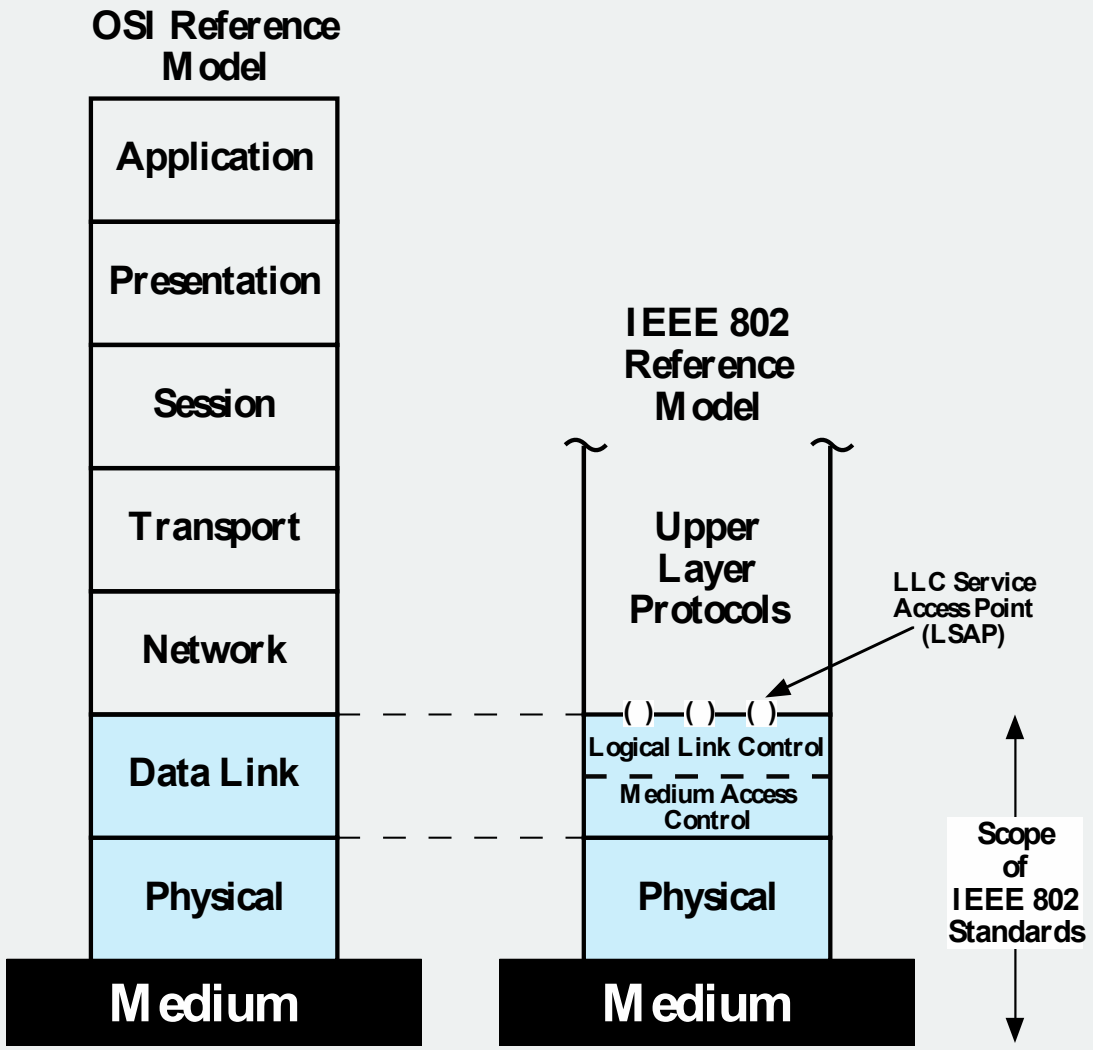


Figure 11.3 IEEE 802 Protocol Layers Compared to OSI Model

IEEE 802 Reference Model

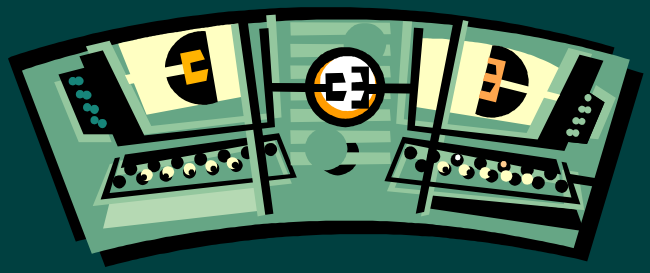
- Lowest layer corresponds to the physical layer of the OSI model
- Includes a specification of the transmission medium and the topology

Includes functions such as:

- Encoding/decoding of signals
- Preamble generation/removal
- Bit transmission/reception

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

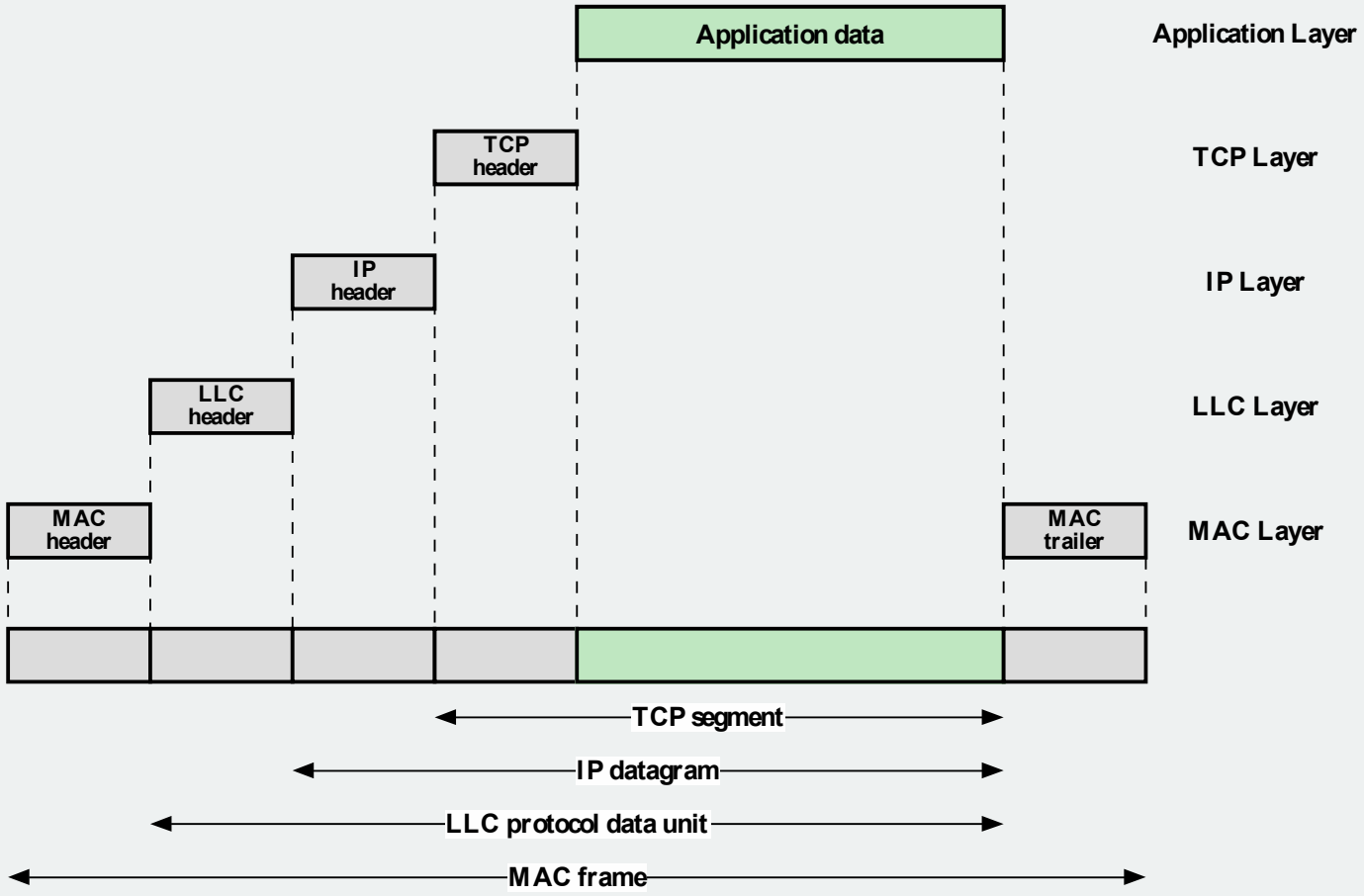


Figure 11.4 LAN Protocols in Context

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

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

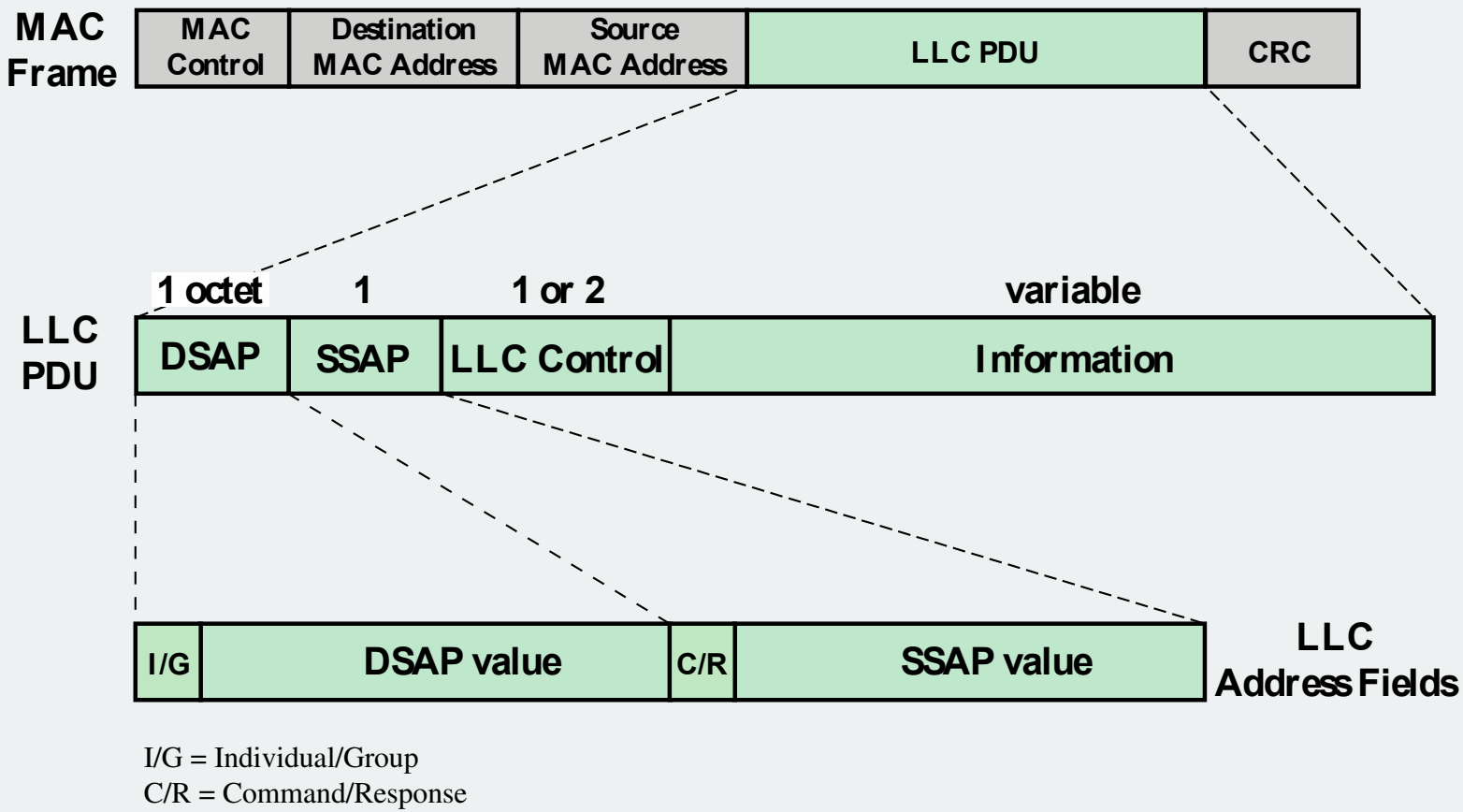


Figure 11.5 LLC PDU in a Generic MAC Frame Format

Medium Access Control (MAC) Protocol

- Controls access to the transmission medium
- Key parameters:
  - **Where**
    - Greater control, single point of failure
    - More complex, but more redundant
  - **How**
    - Synchronous
      - Capacity dedicated to connection, not optimal
    - Asynchronous
      - Response to demand
      - Round robin, reservation, contention

Asynchronous Systems

Round robin

- Each station given turn to transmit data

Reservation

- Divide medium into slots
- Good for stream traffic

Contention

- All stations contend for time
- Good for bursty traffic
- Simple to implement
- Tends 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

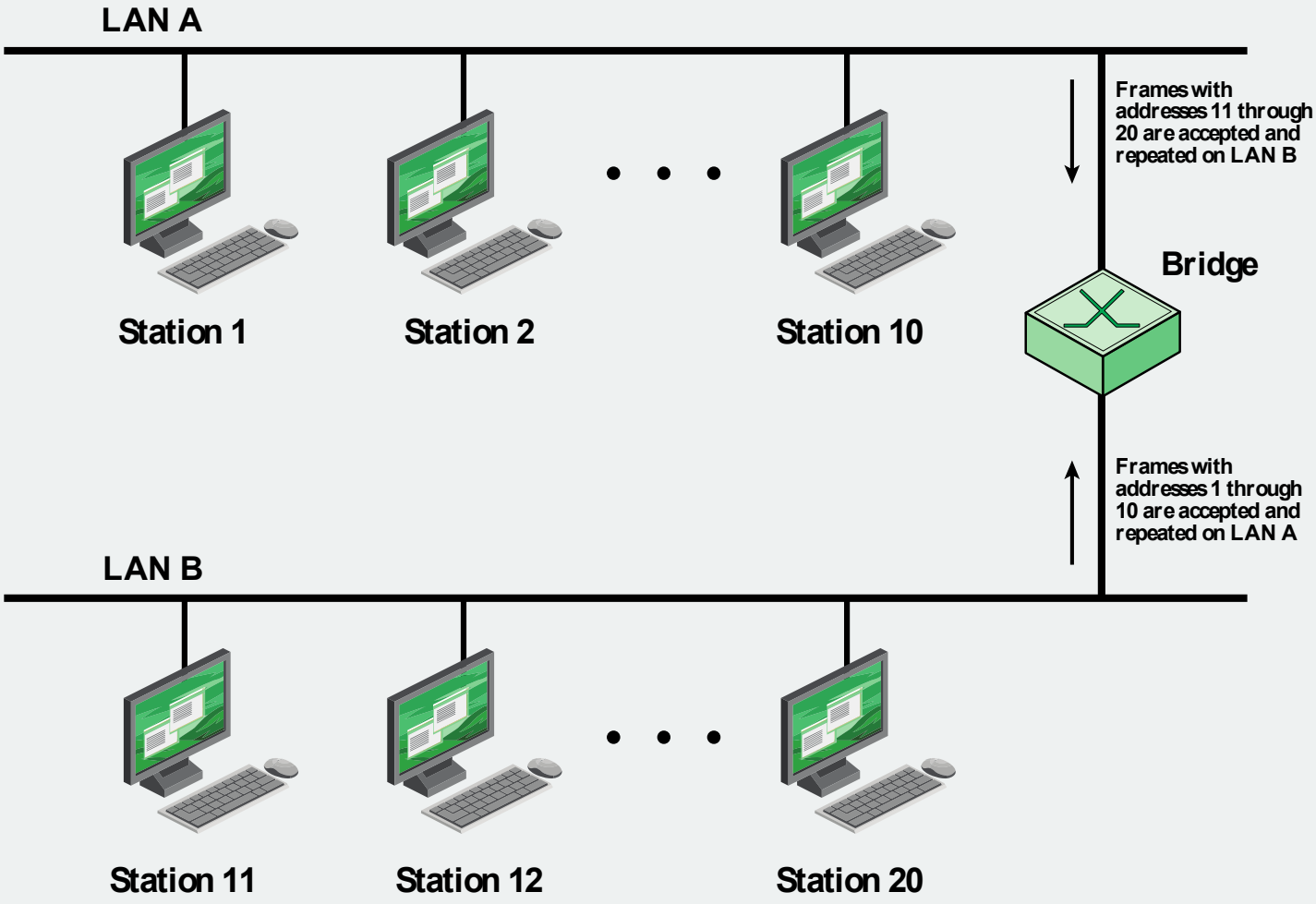


Figure 11.6 Bridge Operation

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

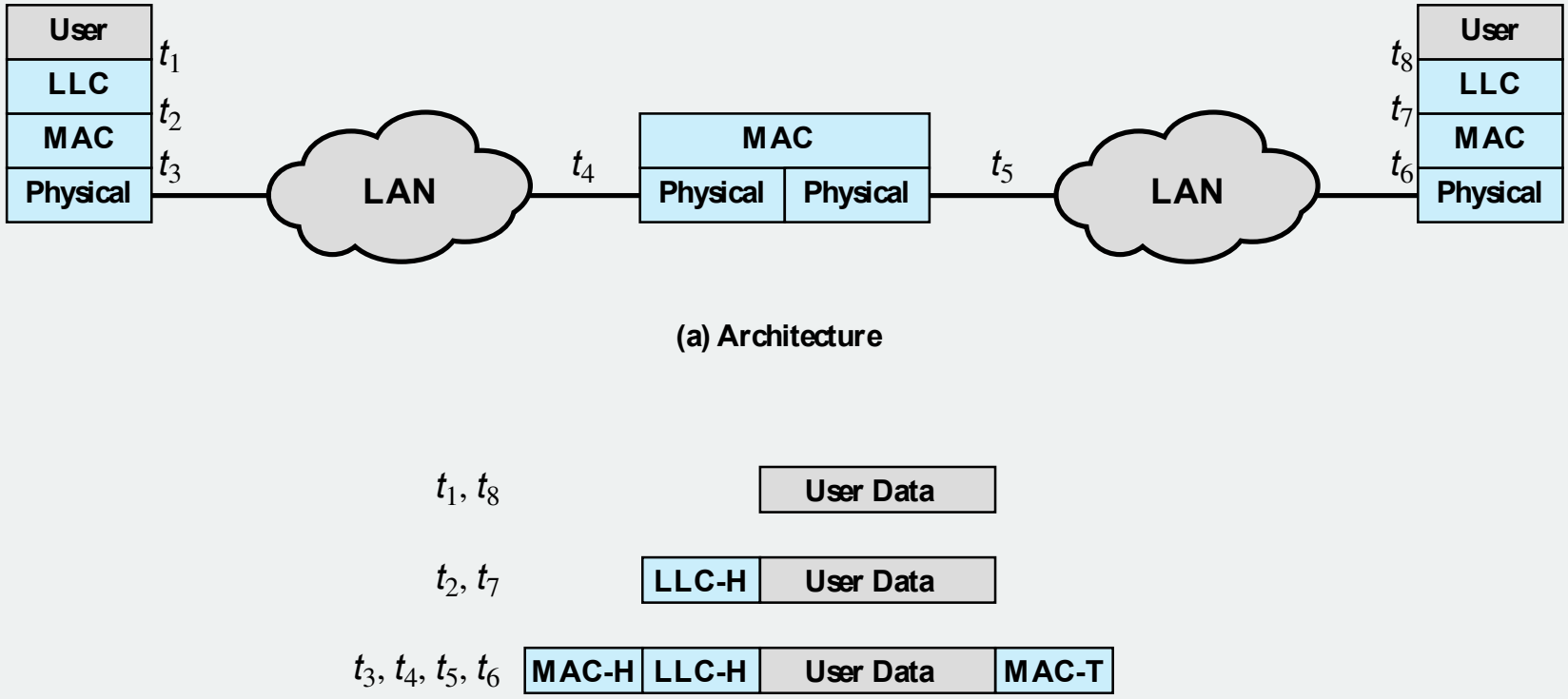


Figure 11.7 Connection of Two LANs by a Bridge

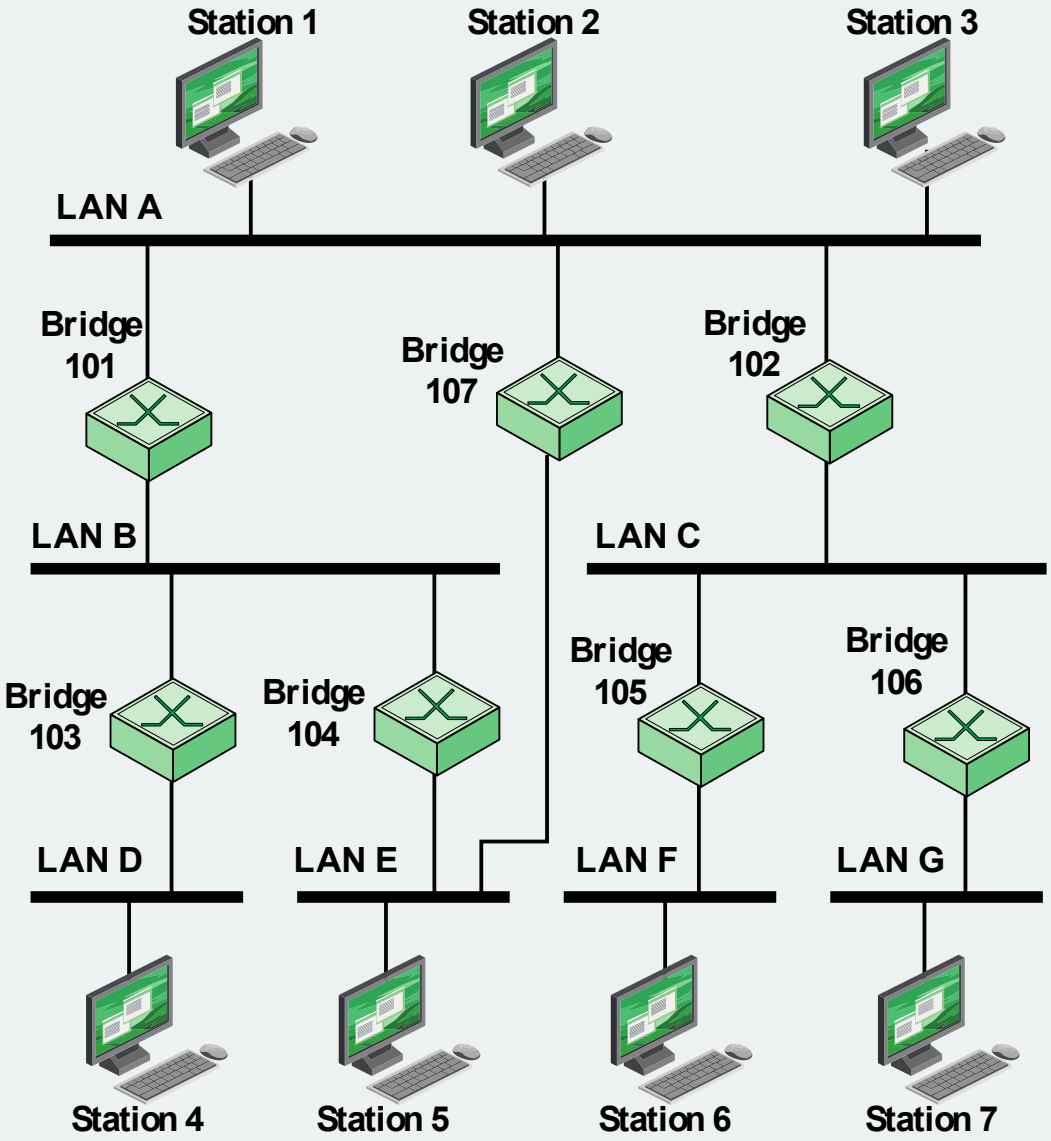
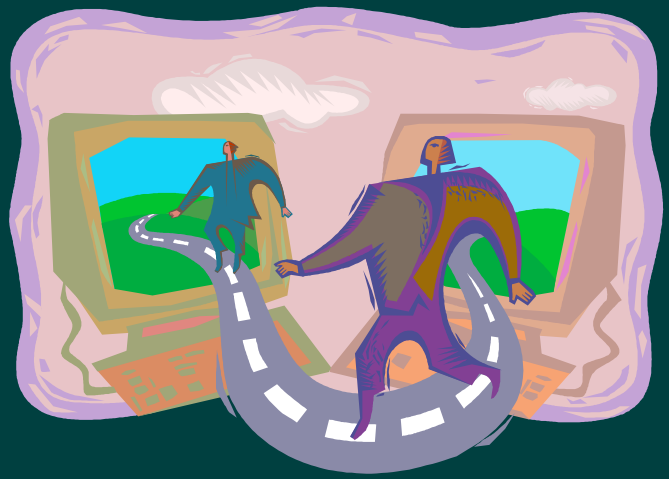


Figure 11.8 Configuration of Bridges and LANs, with Alternate Routes

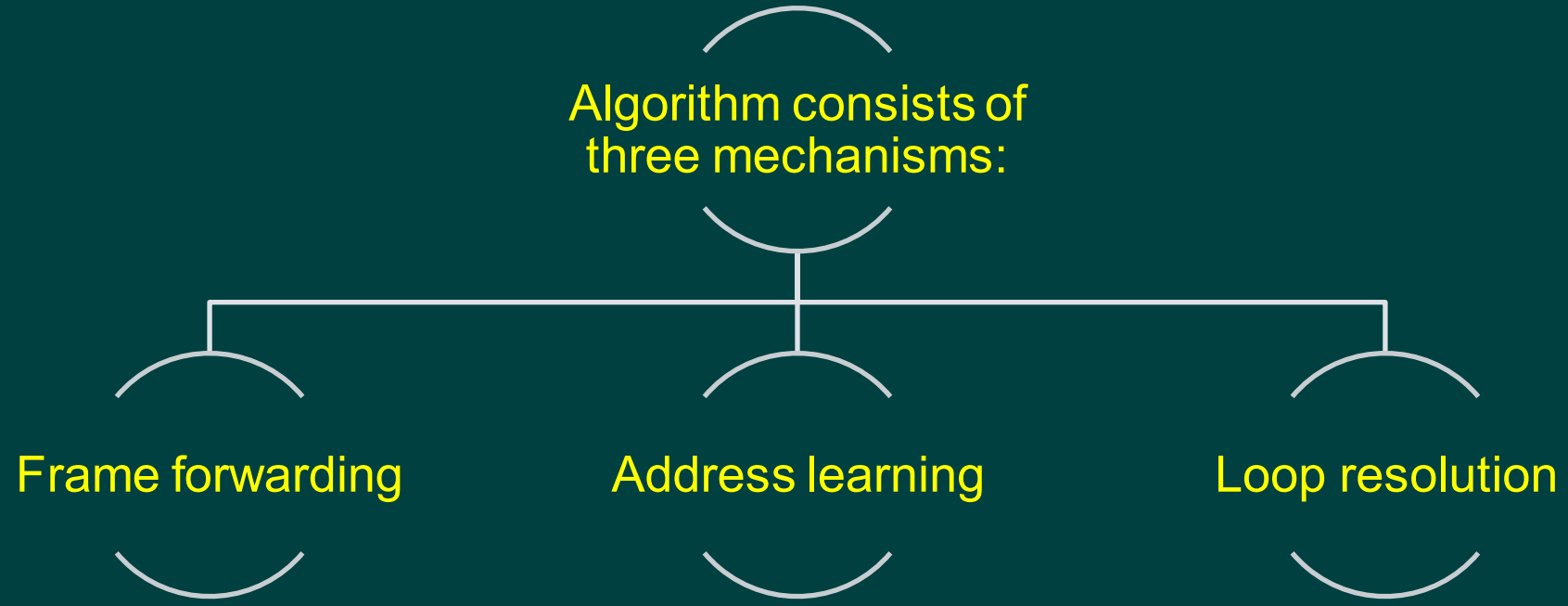
Fixed Routing

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



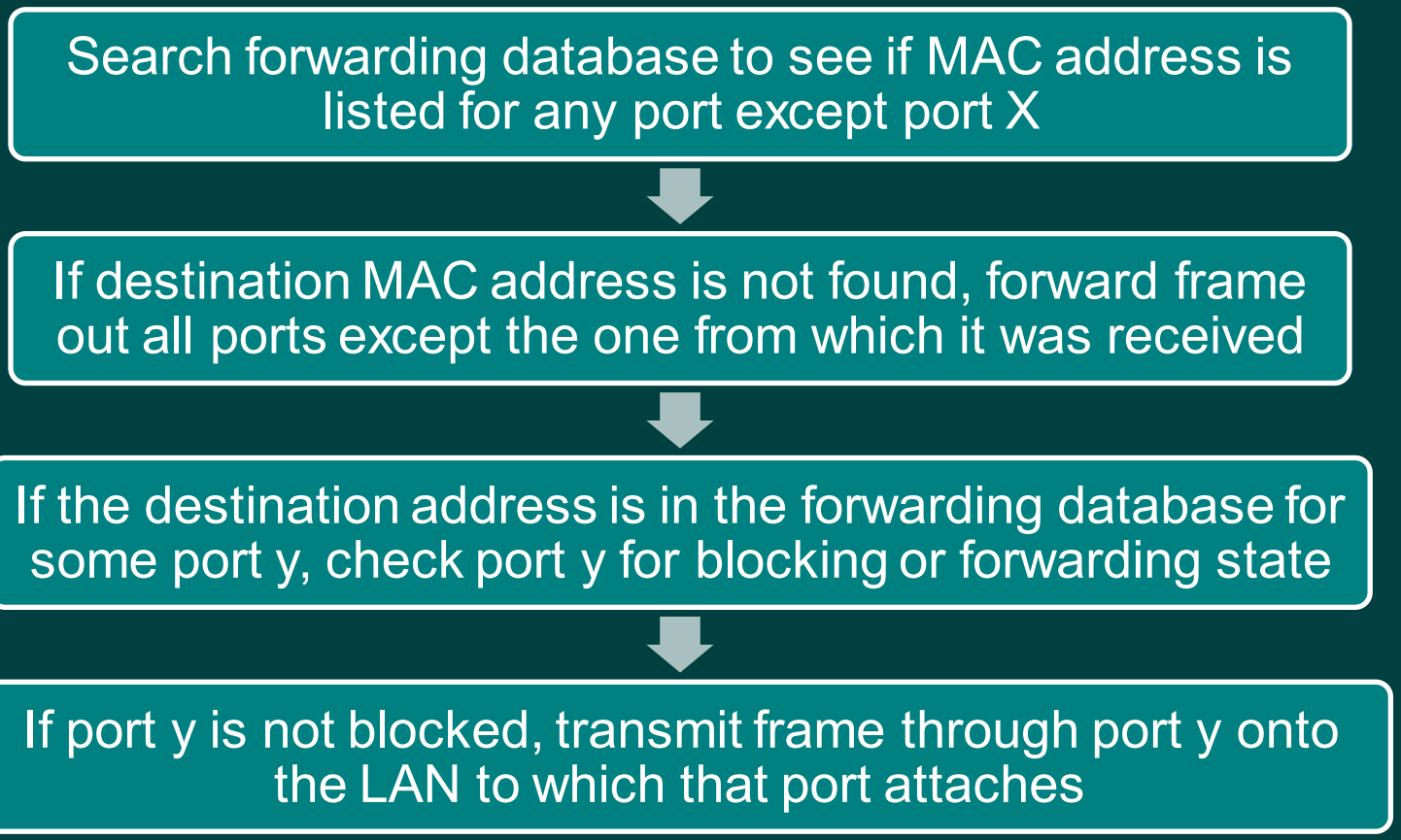
Spanning Tree

- Bridge automatically develops routing table
- Automatically updates routing table in response to changing topology



Frame Forwarding

- Maintain forwarding database for each port attached to a LAN
- For a frame arriving on port X:



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

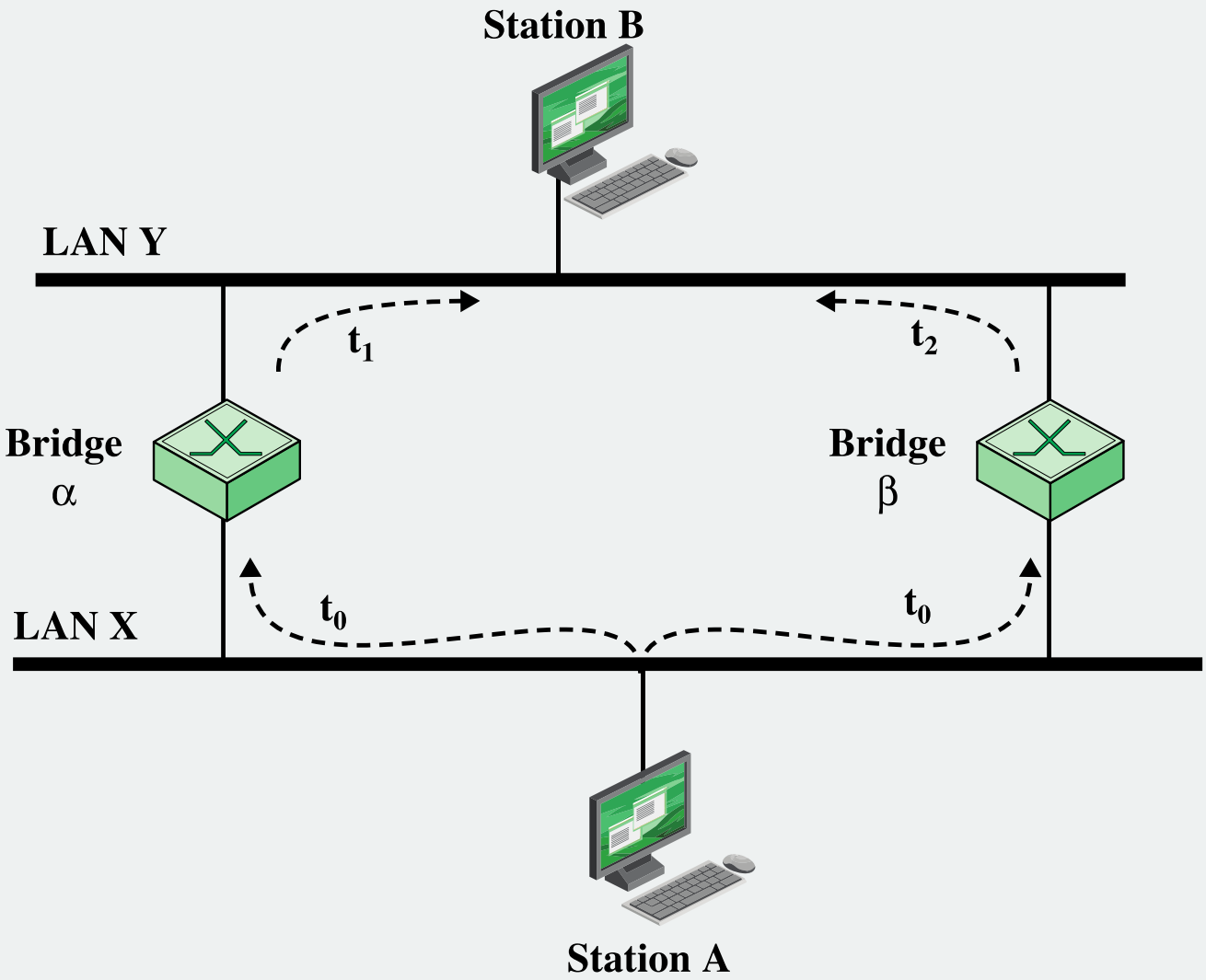


Figure 11.9 Loop of Bridges

Hubs

- Activecentral 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
- Opticalfiber may be used to about 500m
- Physically a star, logically a bus
- Transmissionfrom any one station is received by all other stations
- Iftwo stations transmit at the same time there will be a collision

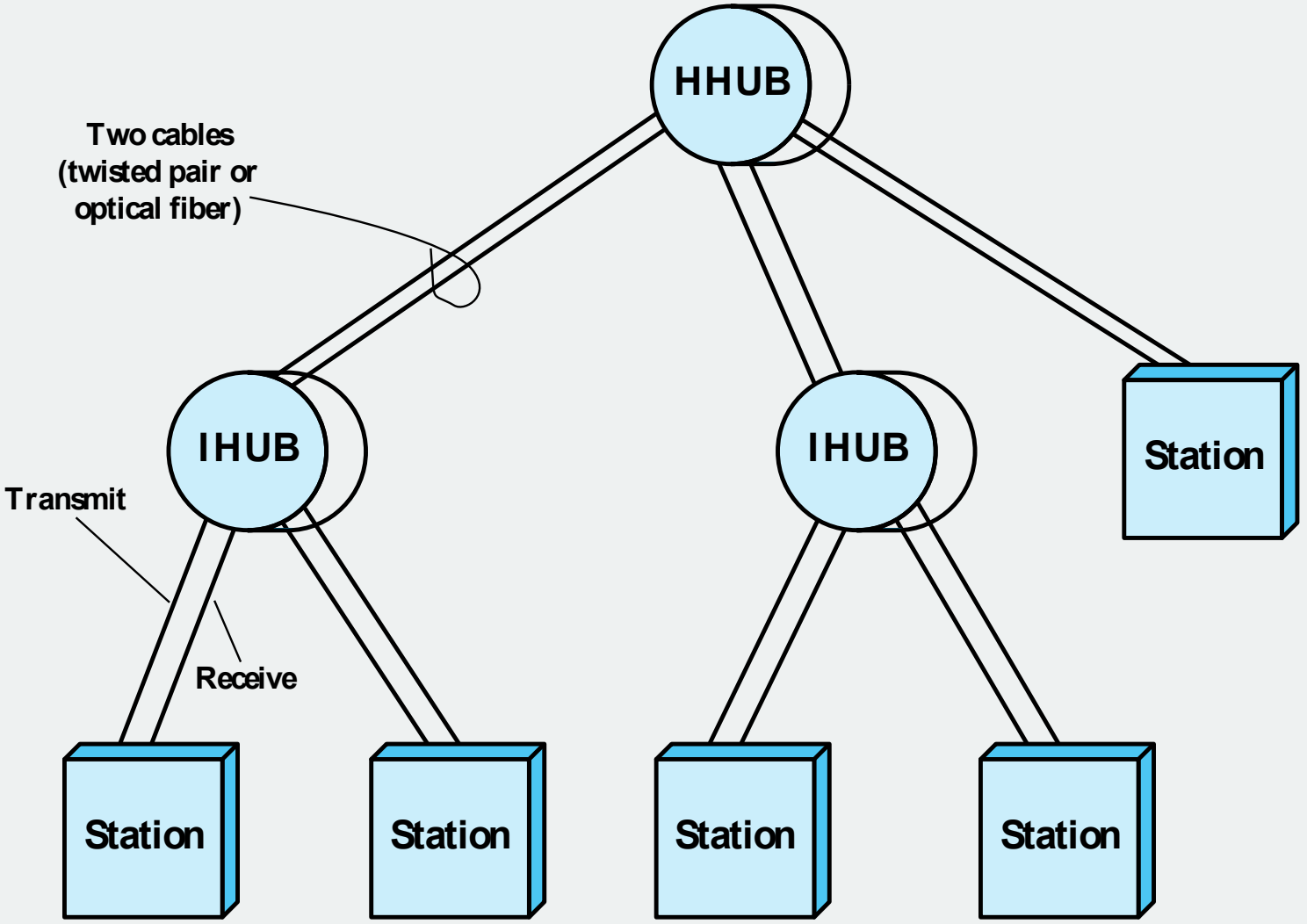


Figure 11.10 Two-Level Star Topology

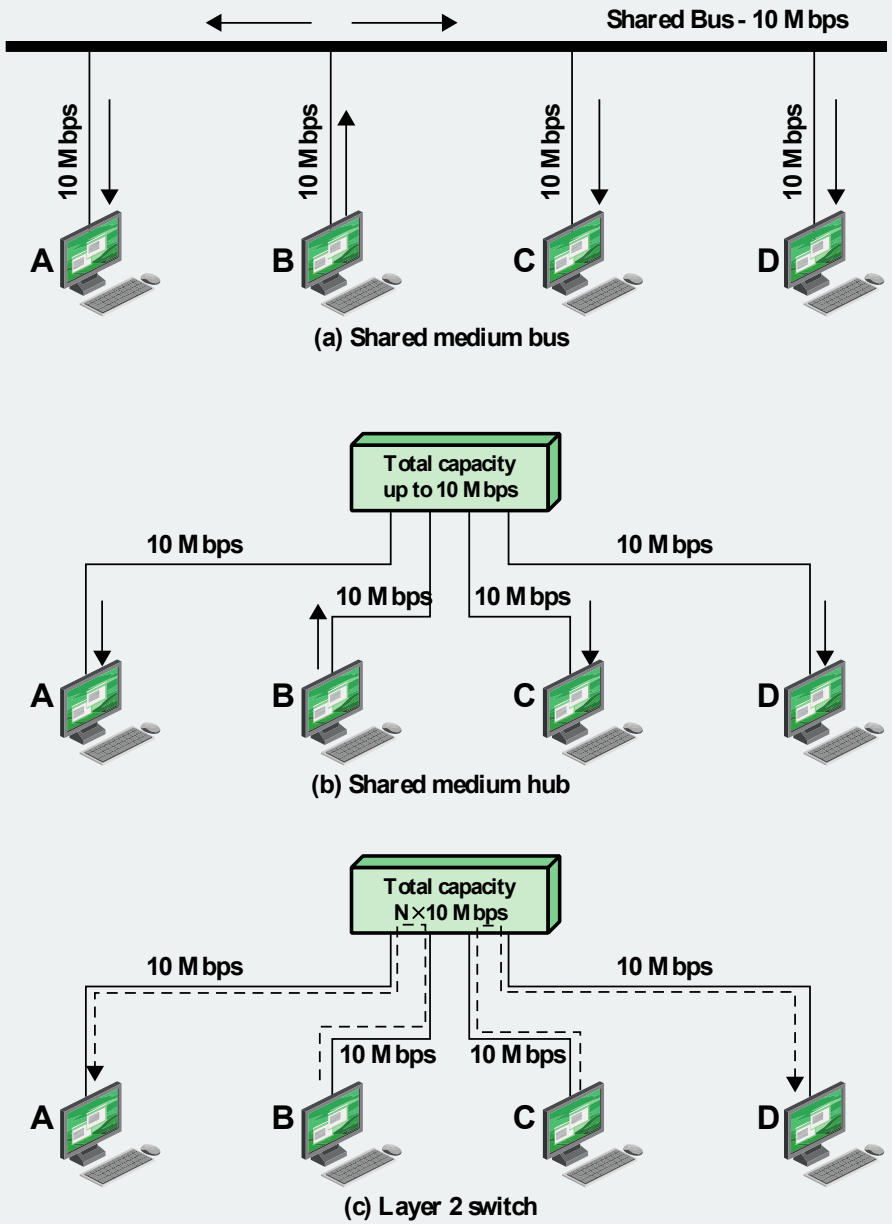


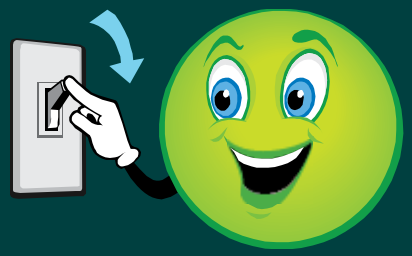
Figure 15.11 LAN Hubs and Switches

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 Switches

- Store-and-forward switch
  - Accepts frame on input line, buffers briefly, routes to appropriate output line
  - See delay between sender and receiver
  - Boosts overall integrity



- Cut-through switch
  - Use destination address at beginning of frame
  - Switch begins repeating frame onto output line as soon as destination address is recognized
  - Yields highest possible throughput
  - Risk of propagating bad frames

Layer 2 Switch vs. Bridge

- Differences between switches and bridges:

Bridge	Switch
Frame handling done in software	Performs frame forwarding in hardware
Analyzes and forwards one frame at a time	Can handle multiple frames at a time
Uses store-and-forward operation	Can have cut-through operation

- Layer2 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

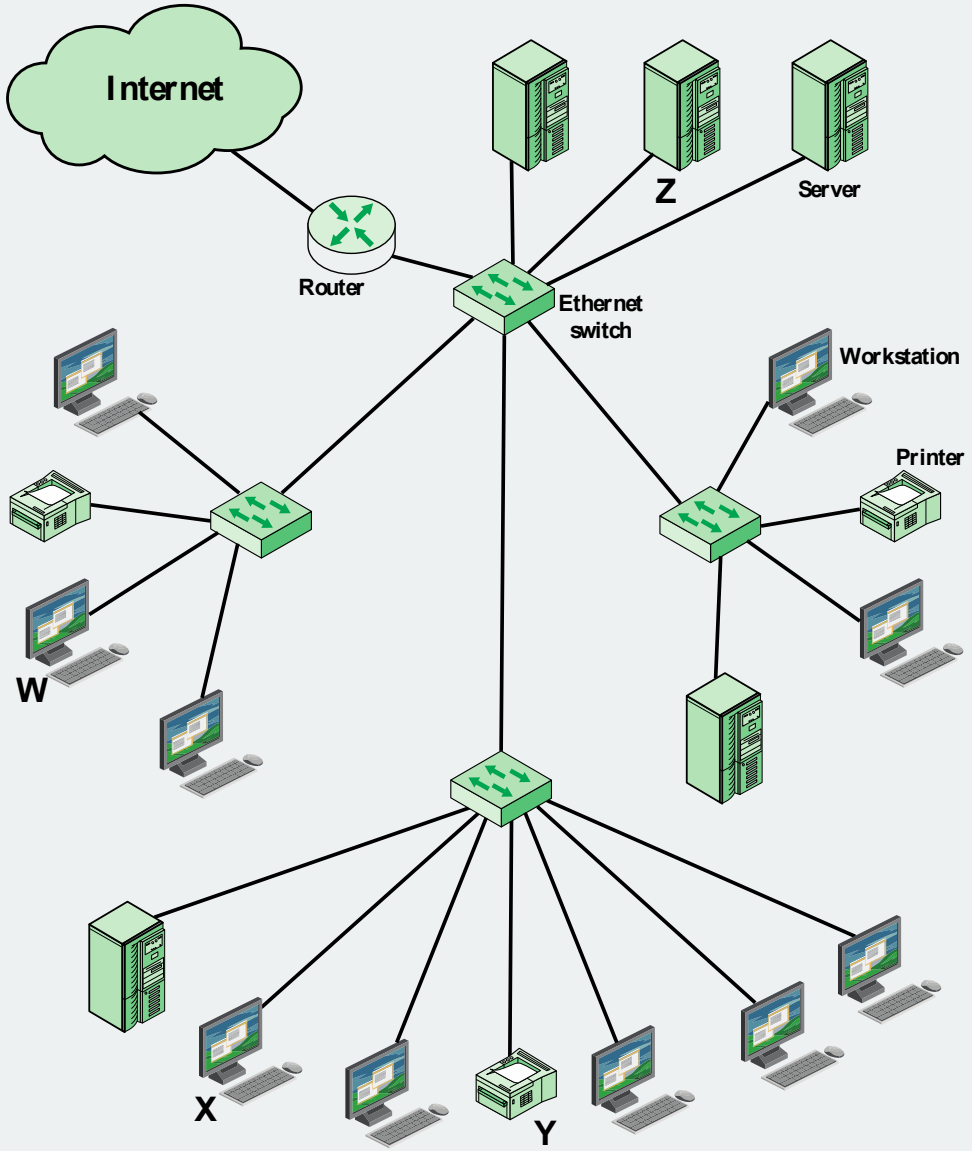


Figure 11.12 A LAN Configuration

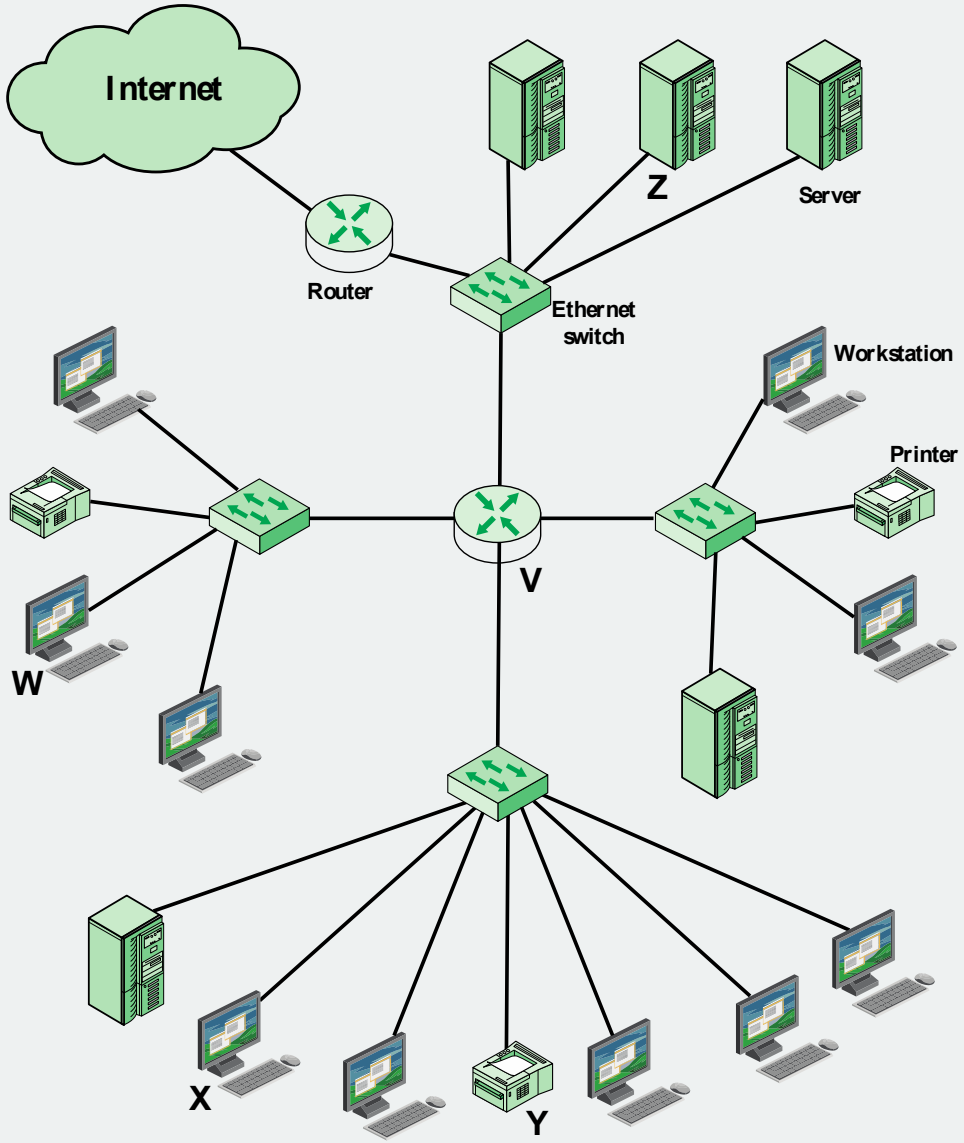


Figure 11.13 A Partitioned LAN

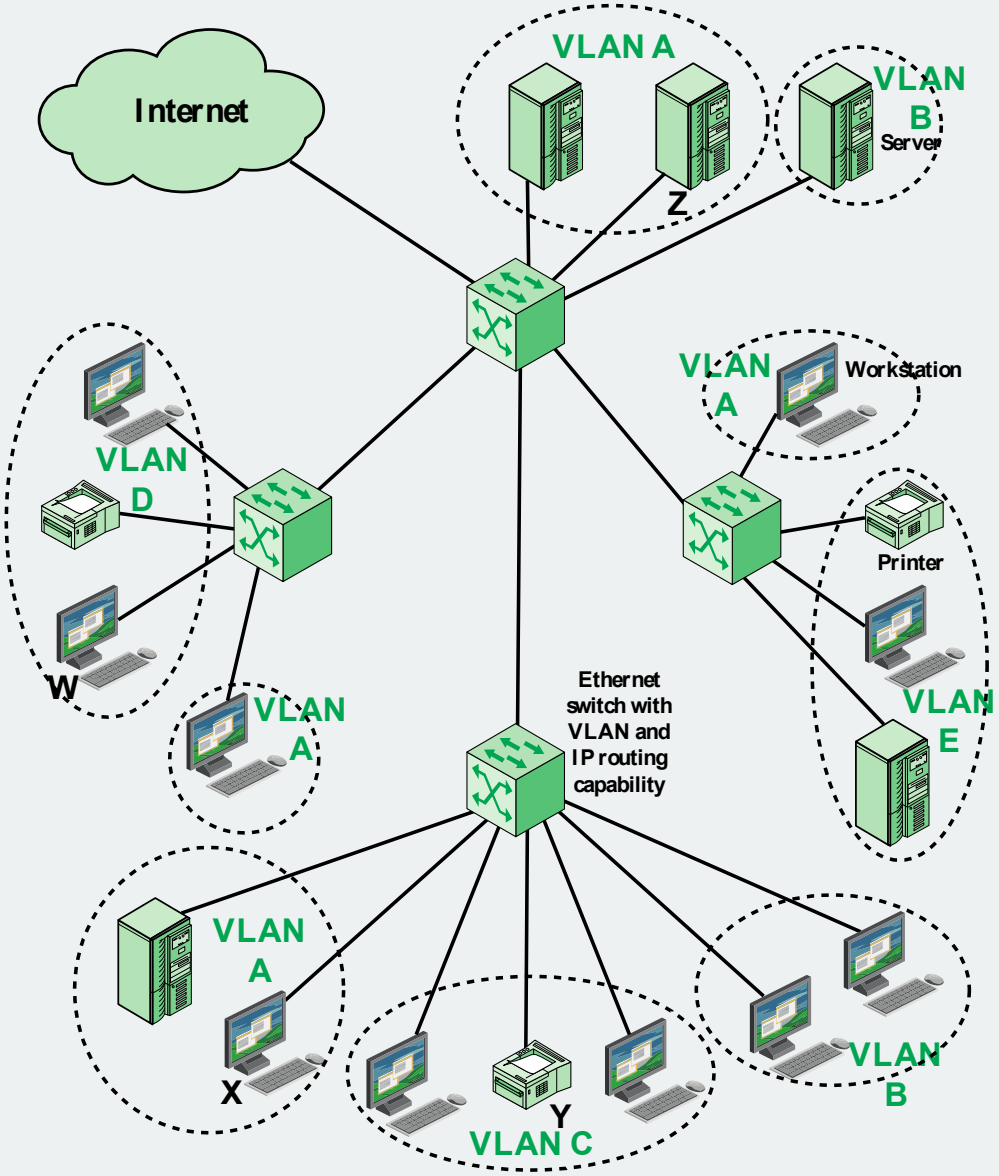


Figure 11.14 A VLAN Configuration

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