Connecting LANs, Backbone Networks, and Virtual LANs

Connecting Devices

Repeaters

Hubs

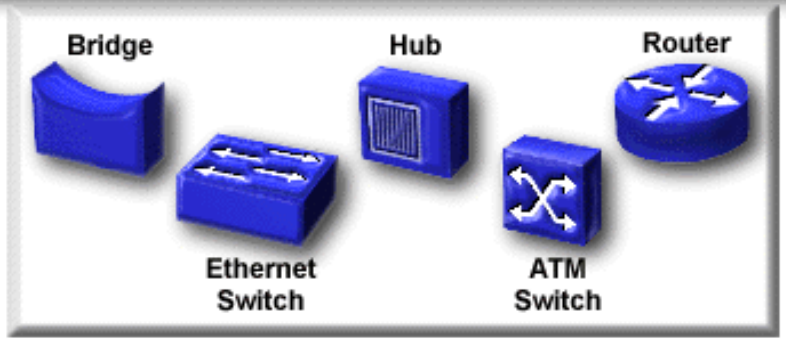
Bridges

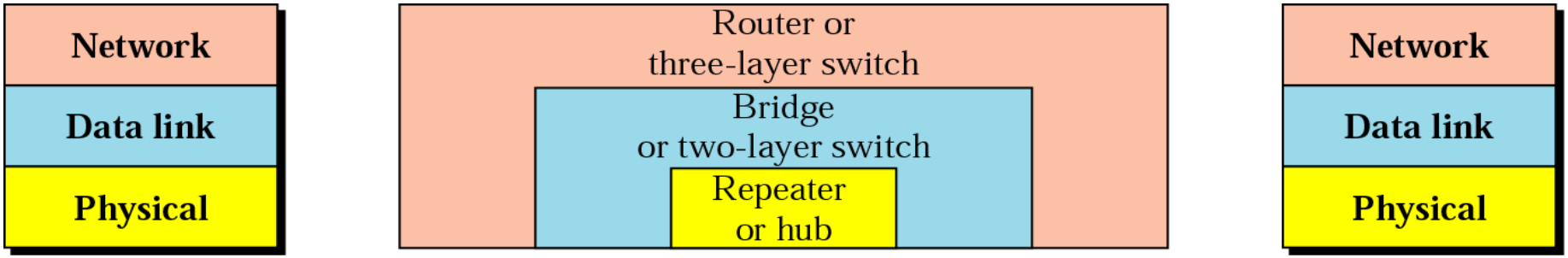
Two-Layer Switches

Connecting devices

Local Area Networks and Devices

- Operate within a limited geographic area
- Allow multiaccess to high-bandwidth media
- Control the network privately under local administration
- Provide full-time connectivity to local services
- Connect physically adjacent devices



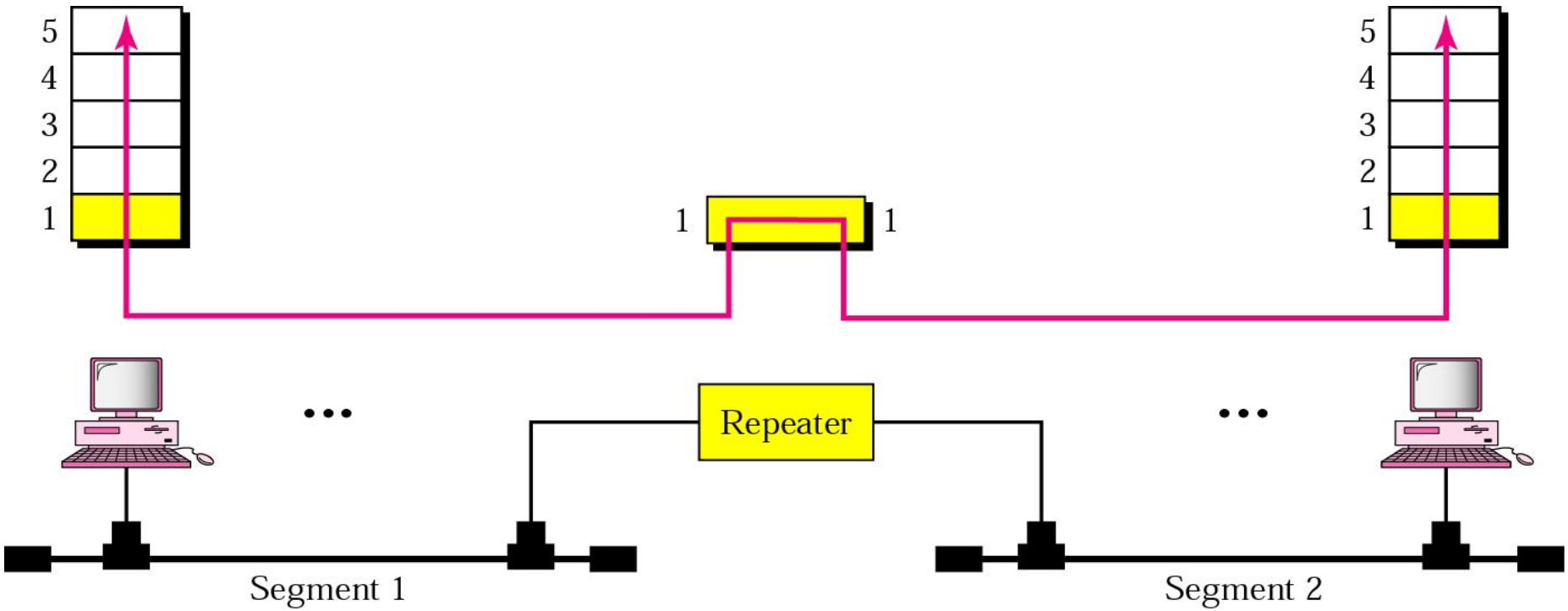


Repeater

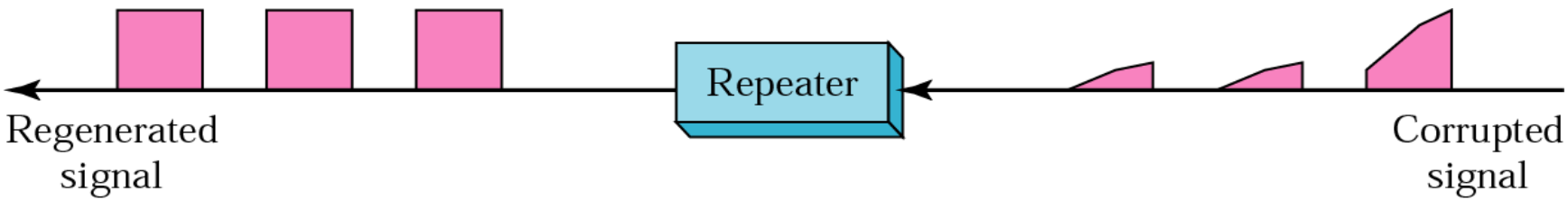
A repeater connects segments of a LAN.

A repeater is a regenerator, not an amplifier.

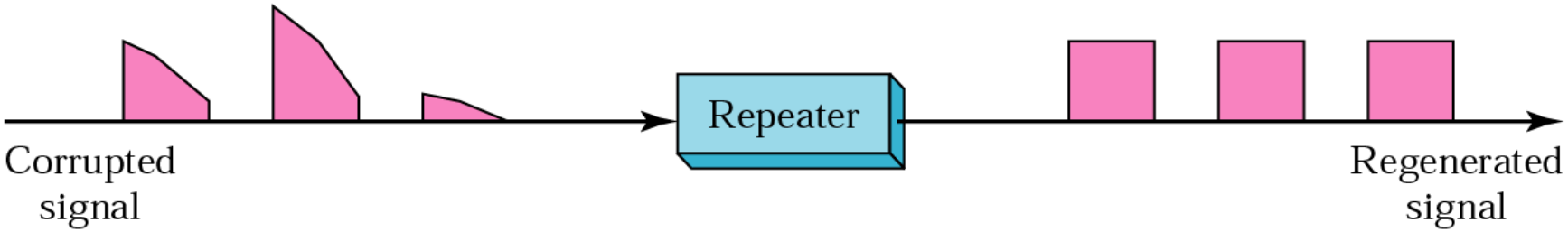
A repeater forwards every frame; it has no filtering capability.



Function of a repeater



a. Right-to-left transmission.

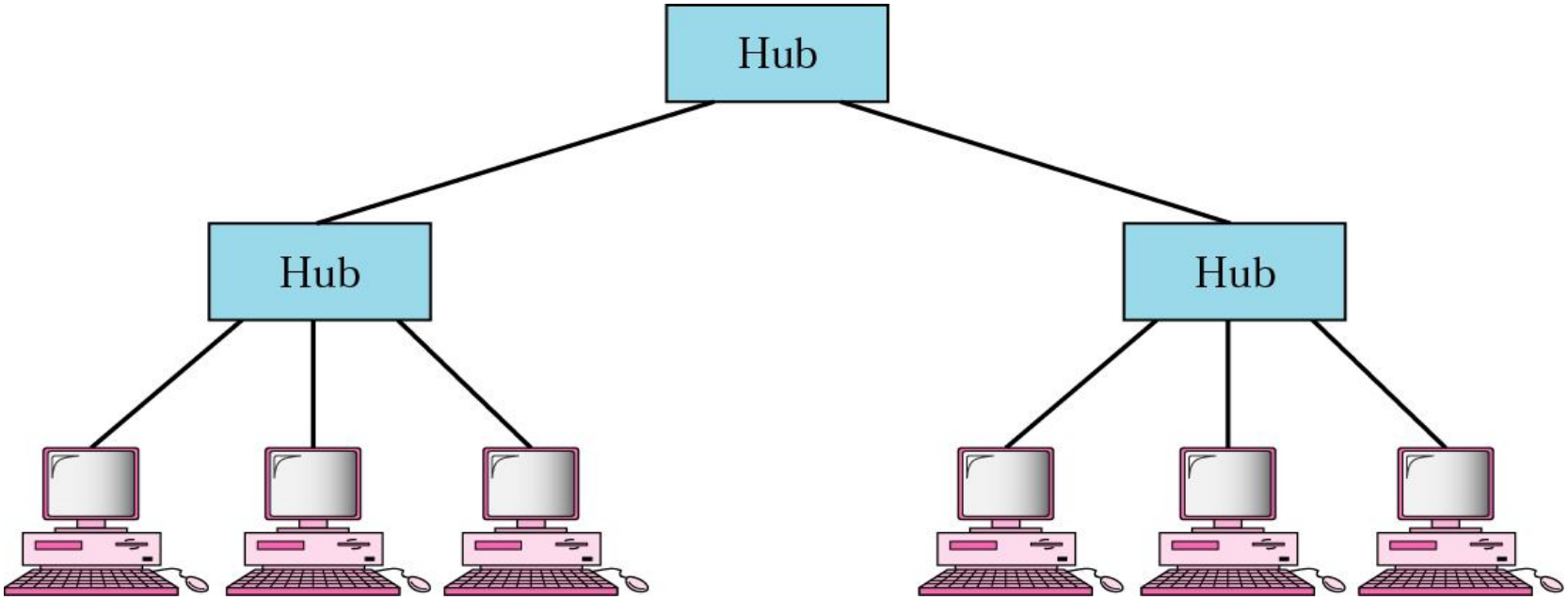


b. Left-to-right transmission.

Hubs

- Active central element of star layout
- Each station connected to hub by two lines
  - Transmit and receive
- Hub acts as a repeater
- When single station transmits, hub repeats signal on outgoing line to each station
- Line consists of two unshielded twisted pairs
- Limited to about 100 m
  - High data rate and poor transmission qualities of UTP
- Optical fiber may be used
  - Max about 500 m
- Physically star, logically bus
- Transmission from any station received by all other stations
- If two stations transmit at the same time, collision

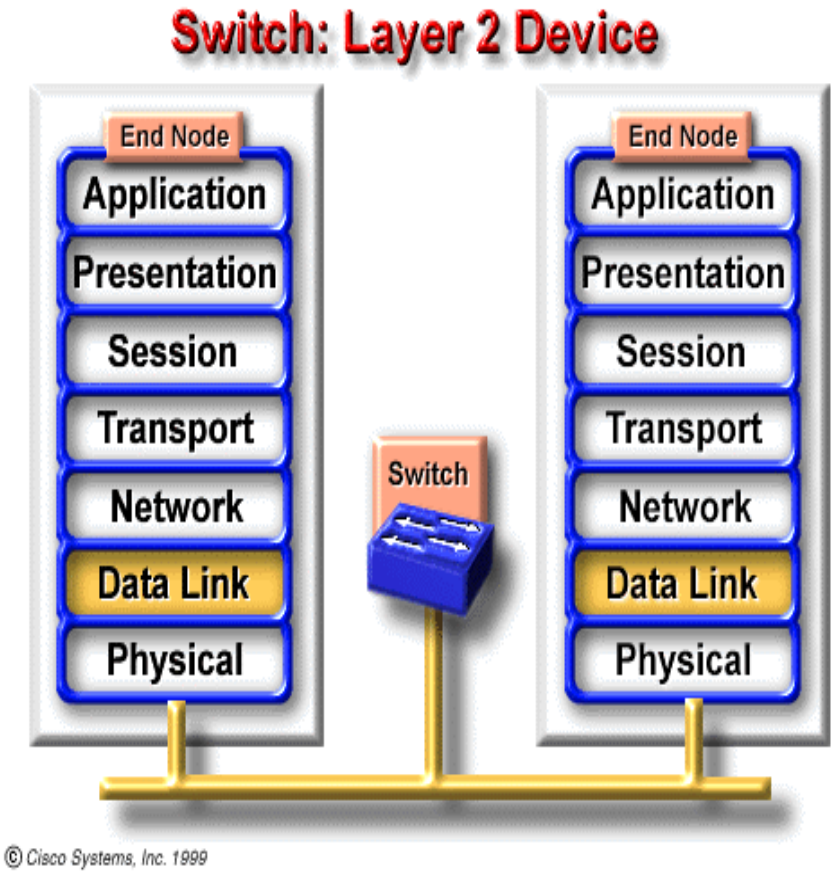
Hubs

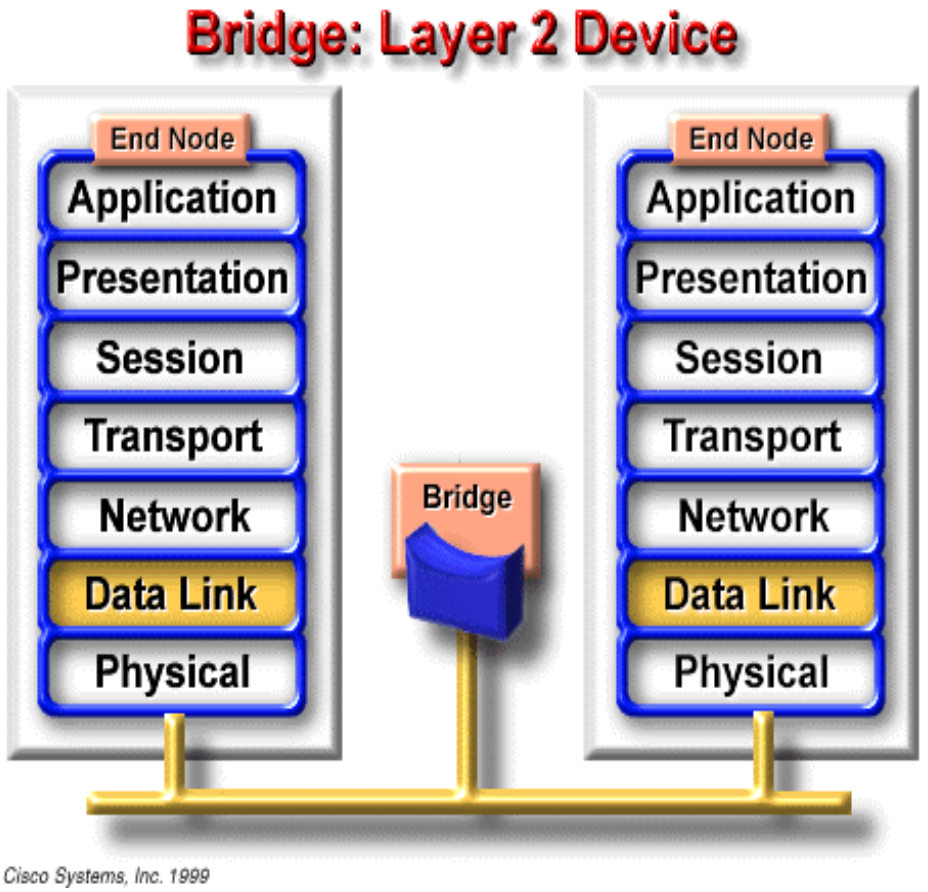


Bridges

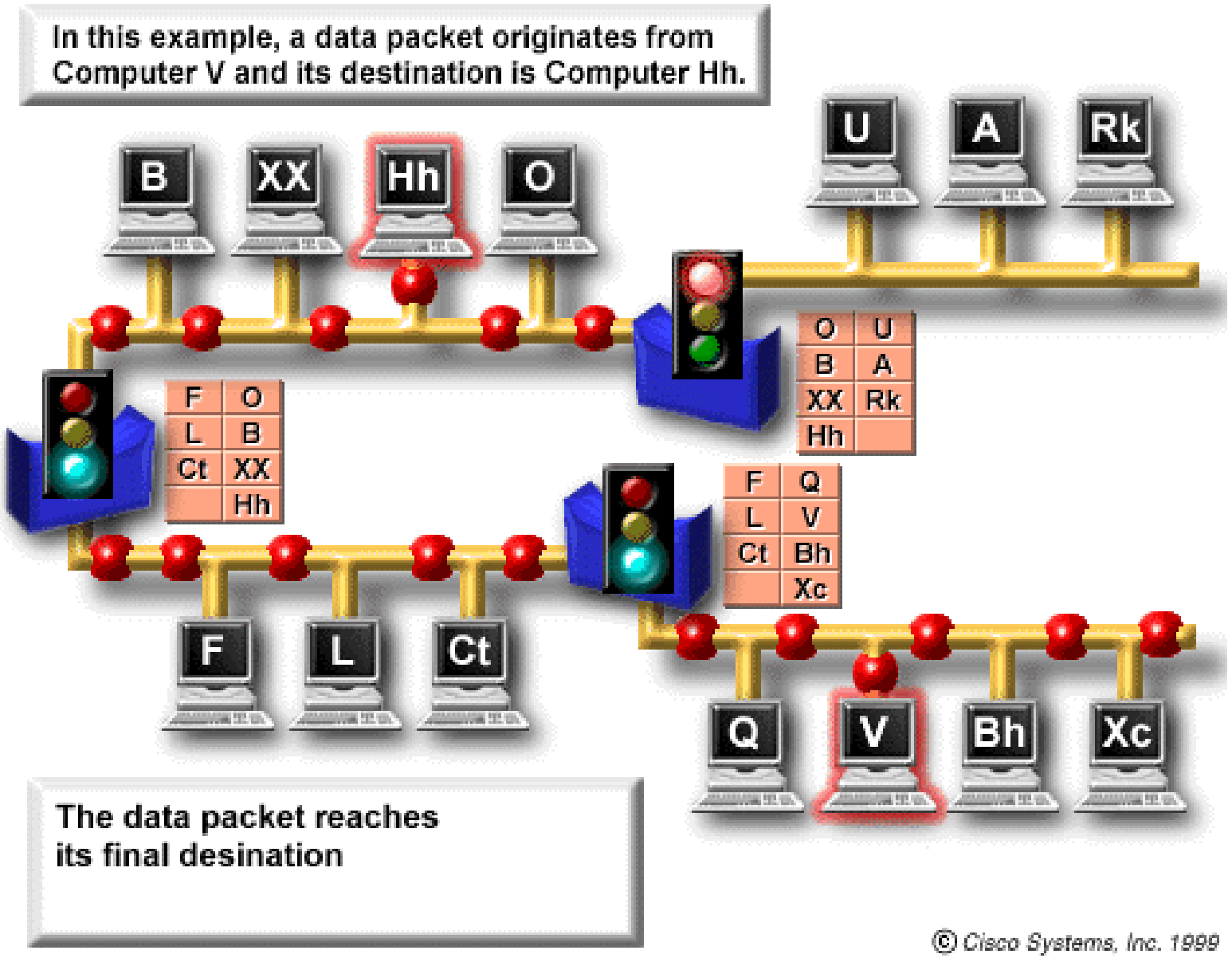
- Ability to expand beyond single LAN
- Provide interconnection to other LANs/WANs
- Use Bridge or router
- Bridge is simpler
  - Connects similar LANs
  - Identical protocols for physical and link layers
  - Minimal processing
- Router more general purpose
  - Interconnect various LANs and WANs

Bridge and Switch





Bridge



Functions of a Bridge

- Read all frames transmitted on one LAN and accept those address to any station on the other LAN
- Using MAC protocol for second LAN, retransmit each frame
- Do the same the other way round

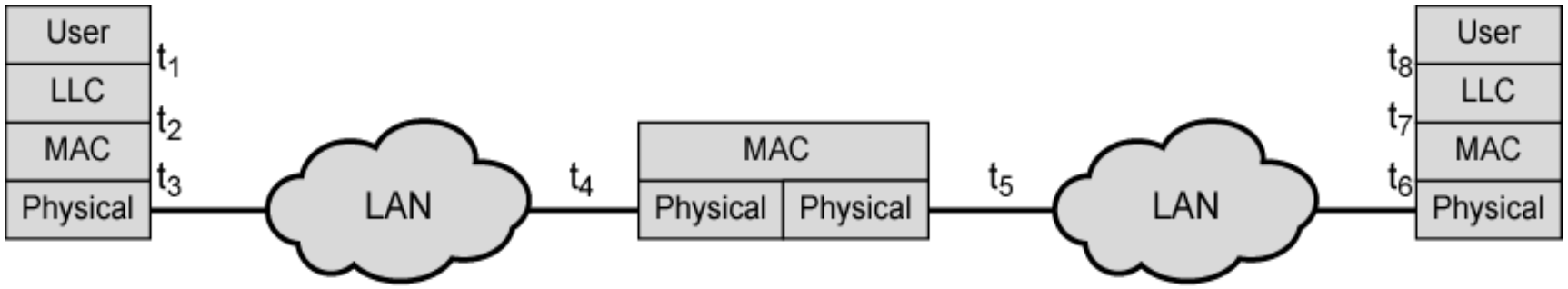
Bridge Design Aspects

- No modification to content or format of frame
- No encapsulation
- Exact bitwise copy of frame
- Minimal buffering to meet peak demand
- Contains routing and address intelligence
  - Must be able to tell which frames to pass
  - May be more than one bridge to cross
- May connect more than two LANs
- Bridging is transparent to stations
  - Appears to all stations on multiple LANs as if they are on one single LAN

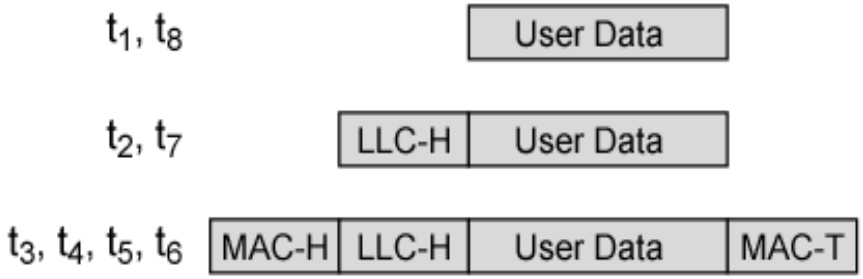
Bridge Protocol Architecture

- IEEE 802.1D
- MAC level
  - Station address is at this level
- Bridge does not need LLC layer
  - It is relaying MAC frames
- Can pass frame over external communications system
  - e.g. WAN link
  - Capture frame
  - Encapsulate it
  - Forward it across link
  - Remove encapsulation and forward over LAN link

Connection of Two LANs



(a) Architecture

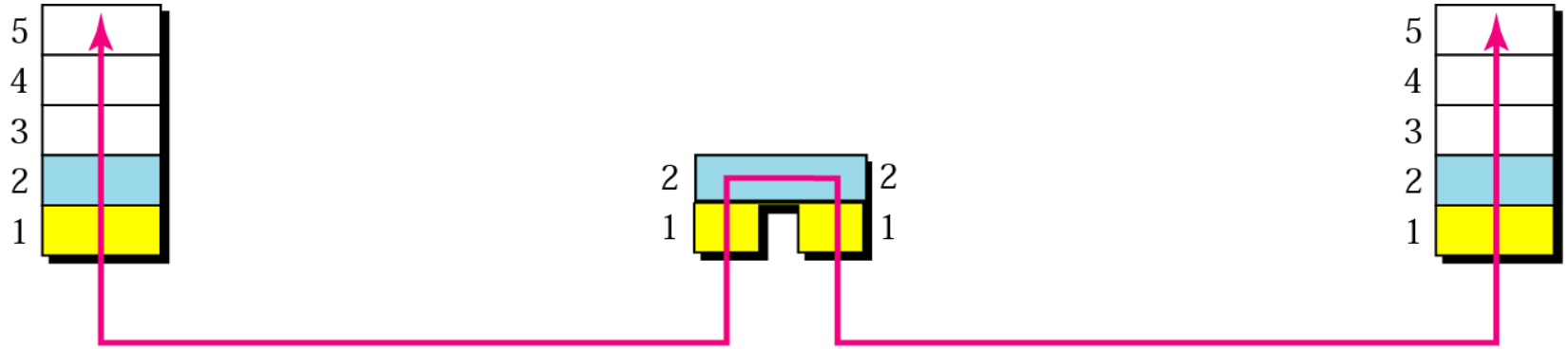


(b) Operation

Bridge

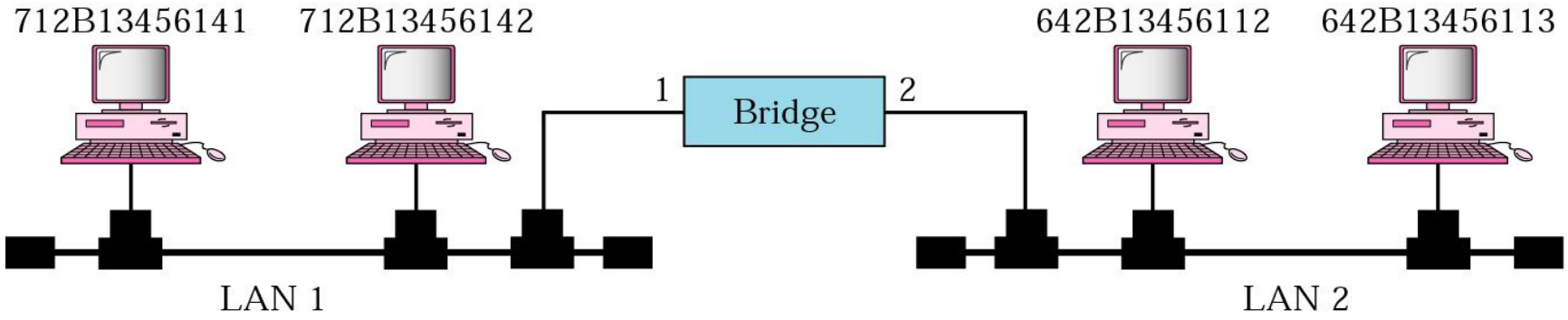
A bridge has a table used in filtering decisions.

A bridge does not change the physical (MAC) addresses in a frame.

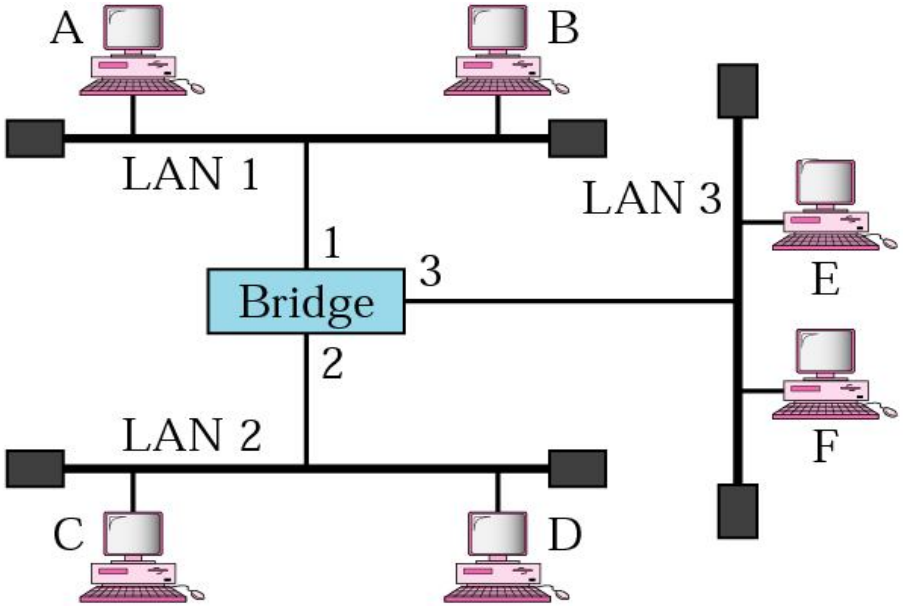


Address	Port
712B13456141	1
712B13456142	1
642B13456112	2
642B13456113	2

Bridge Table



Learning bridge



Address	Port

a. Original

Address	Port
A	1

b. After A sends a frame to D

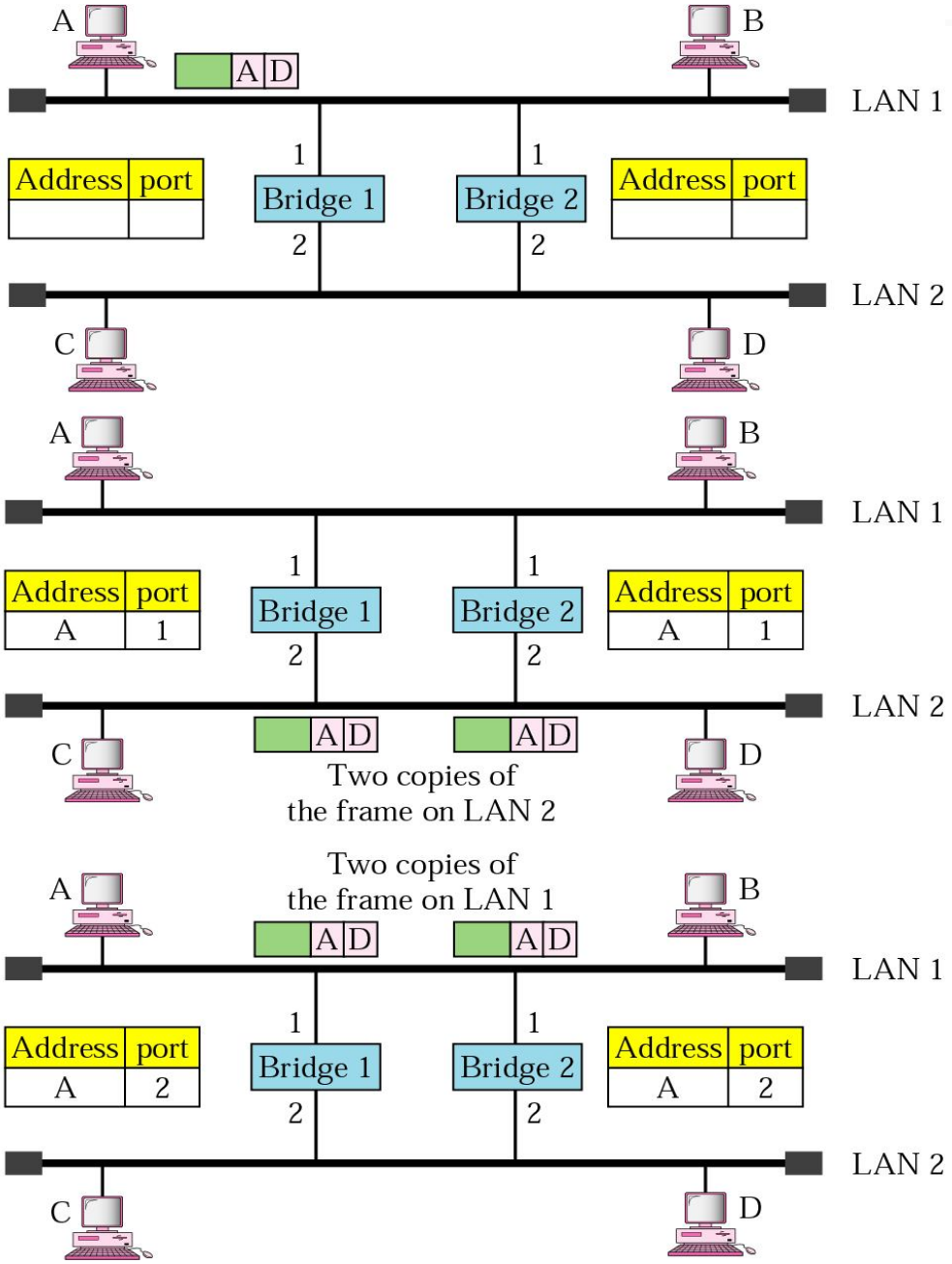
Address	Port
A	1
E	3

c. After E sends a frame to A

Address	Port
A	1
E	3
B	1

d. After B sends a frame to C

Loop problem



The tables are empty. Both update their table

The Copy sent out by bridge 1 is received by bridge 2, which does not information about destination address D. The copy sent out by bridge 2 is resent by bridge 1

The process continue

on and on

Spanning Tree

- Bridge automatically develops routing table
- Automatically update in response to changes
- Frame forwarding
- Address learning
- Loop resolution

Spanning tree

- Spanning tree is a graph in which there is no loop
- In bridged LAN this means creating a topology in which each LAN can be reached from any other LAN thought one path only (no loop)
- We cannot change the physical topology but we can create a logical topology that overlays the physical one.

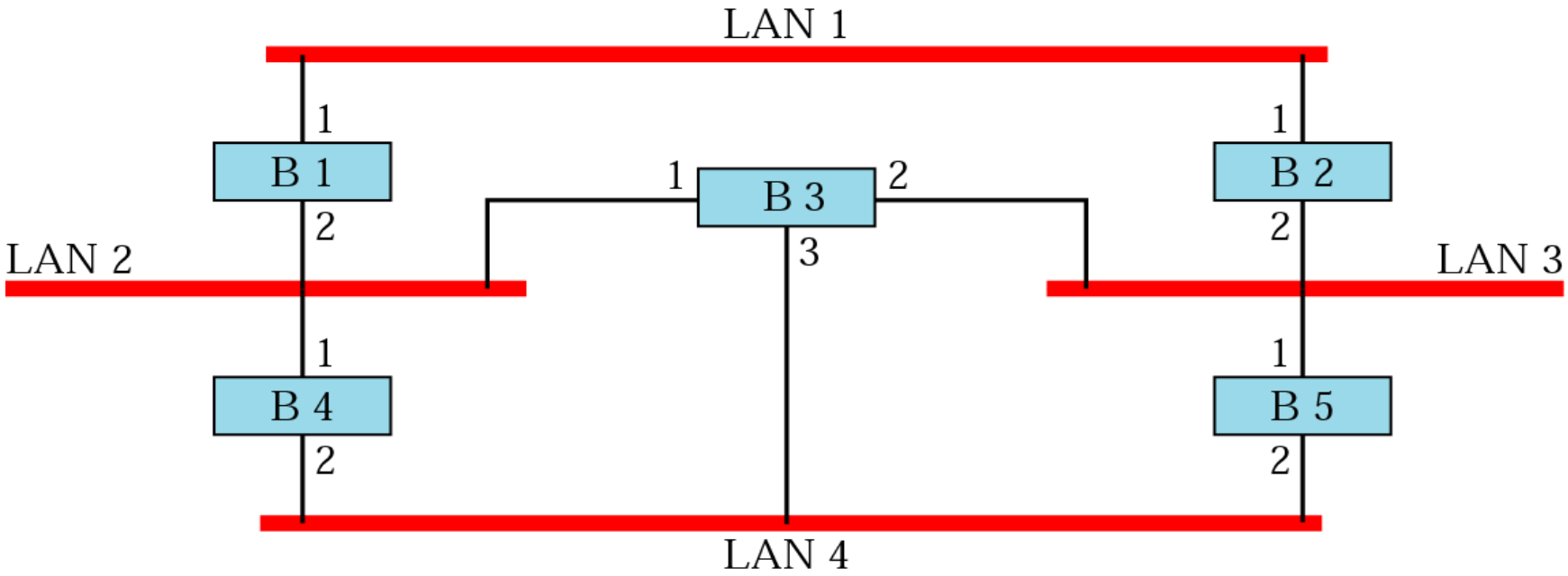
Spanning Tree Algorithm

- Address learning works for tree layout
  - i.e. no closed loops
- For any connected graph there is a spanning tree that maintains connectivity but contains no closed loops
- Each bridge assigned unique identifier
- Exchange between bridges to establish spanning tree

The steps

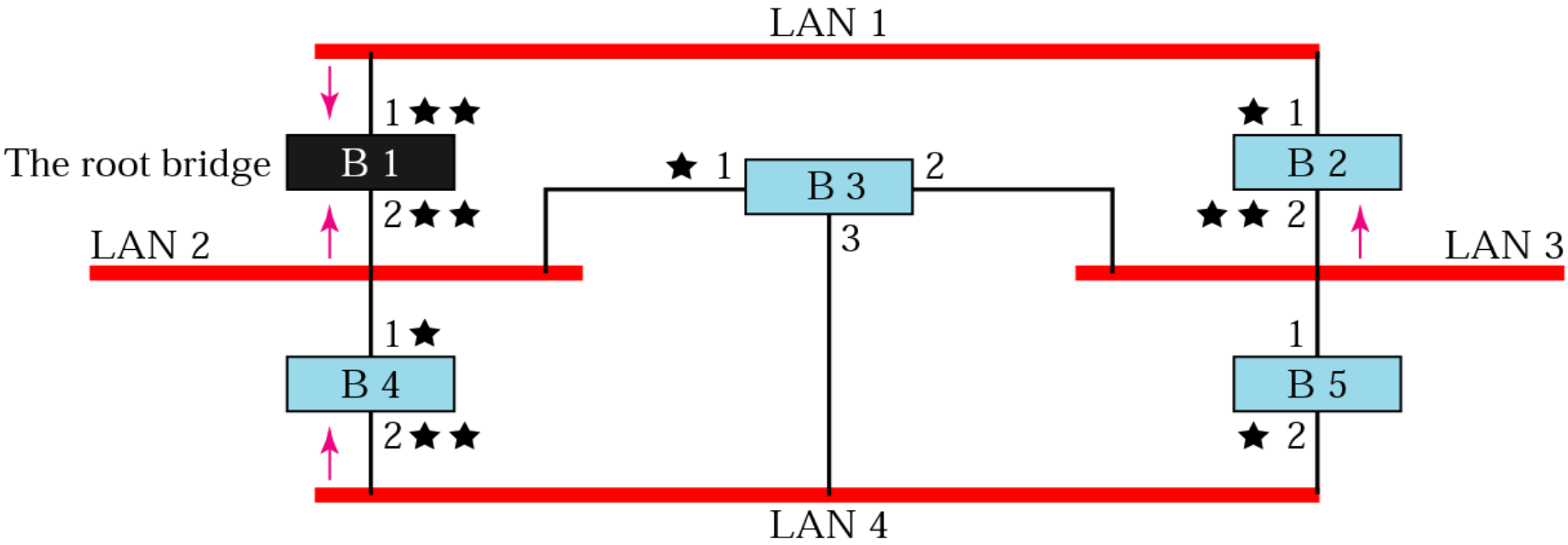
- Every bridge has a build-in ID. The one with the smallest ID is selected as **root bridge.**
- Mark one port of each bridge (except for root bridge) as the **root port**. The interpretation of least-cost path is left up to the system admin (can be min number of hops)
- Choose the *designated bridge* for each LAN. A designed bridge has the least-cost path between LAN and the root bridge. Make the corresponding port the *designed port*. If two bridges have the same least-cost value, chose one with the smaller ID.
- Mark the root port and designed port as ***forwarding ports***, the others as ***blocking ports***.

Prior to spanning tree application



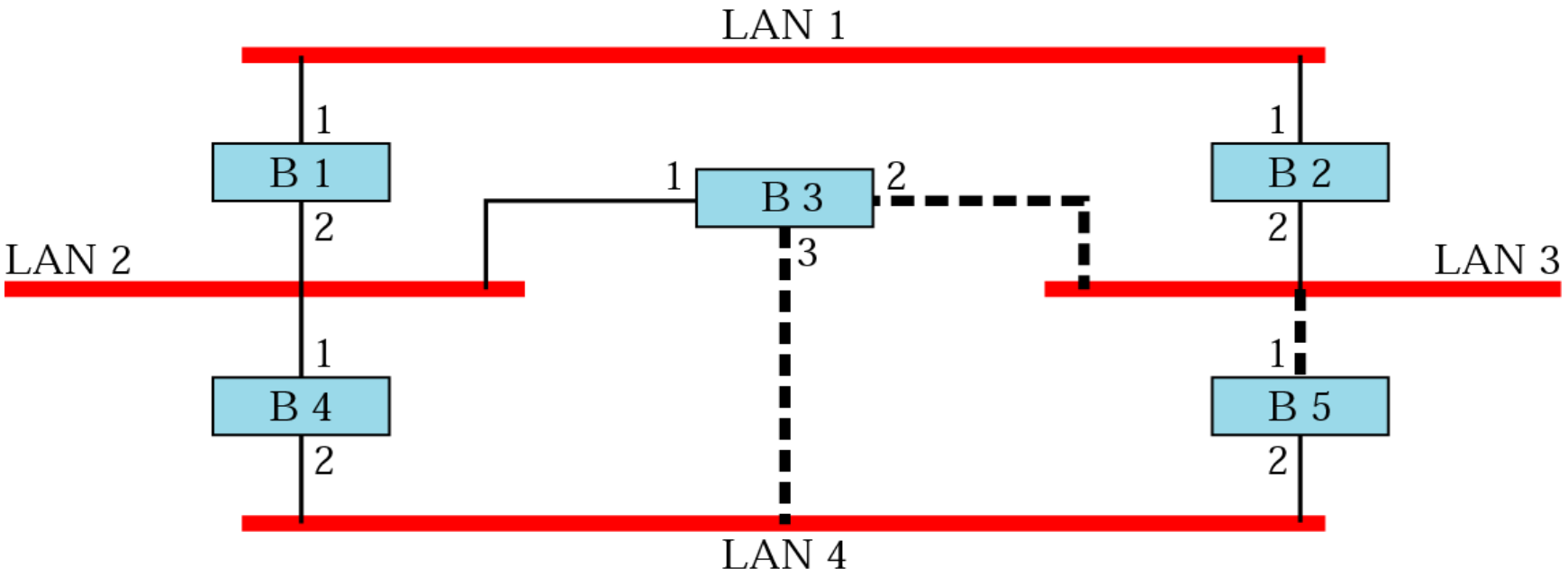
Applying spanning tree

- B1 has the least ID -> B1 root bridge
- The **root ports** are marked with *
- The **designed bridges** has an arrow pointed to them from corresponding LAN
- Designed ports are marked by **



Forwarding ports and blocking ports

- **The root ports and the designed ports as forwarding ports.**
- **The others are blocking ports.**
- **The physical connection is there but the bridge never forwards any from from these ports.**



Backbone Networks

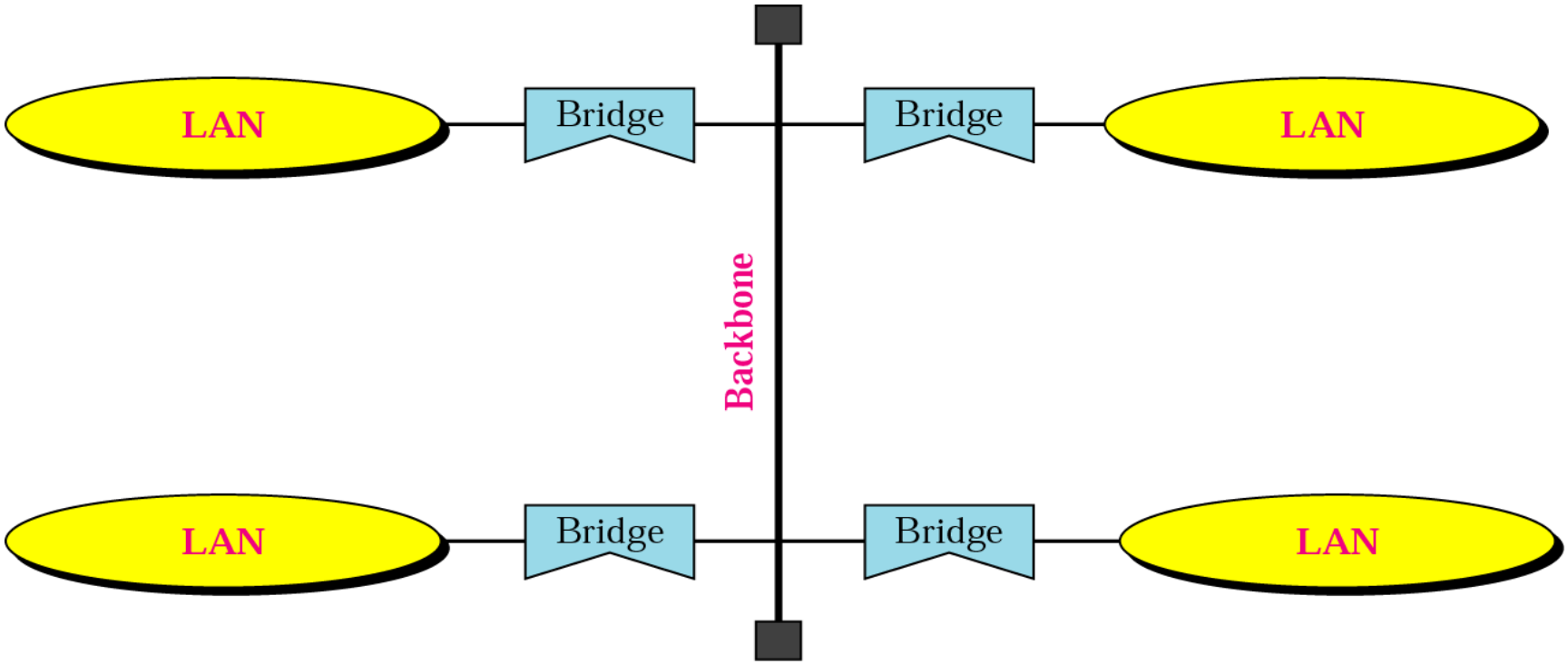
Bus Backbone

Star Backbone

Connecting Remote LANs

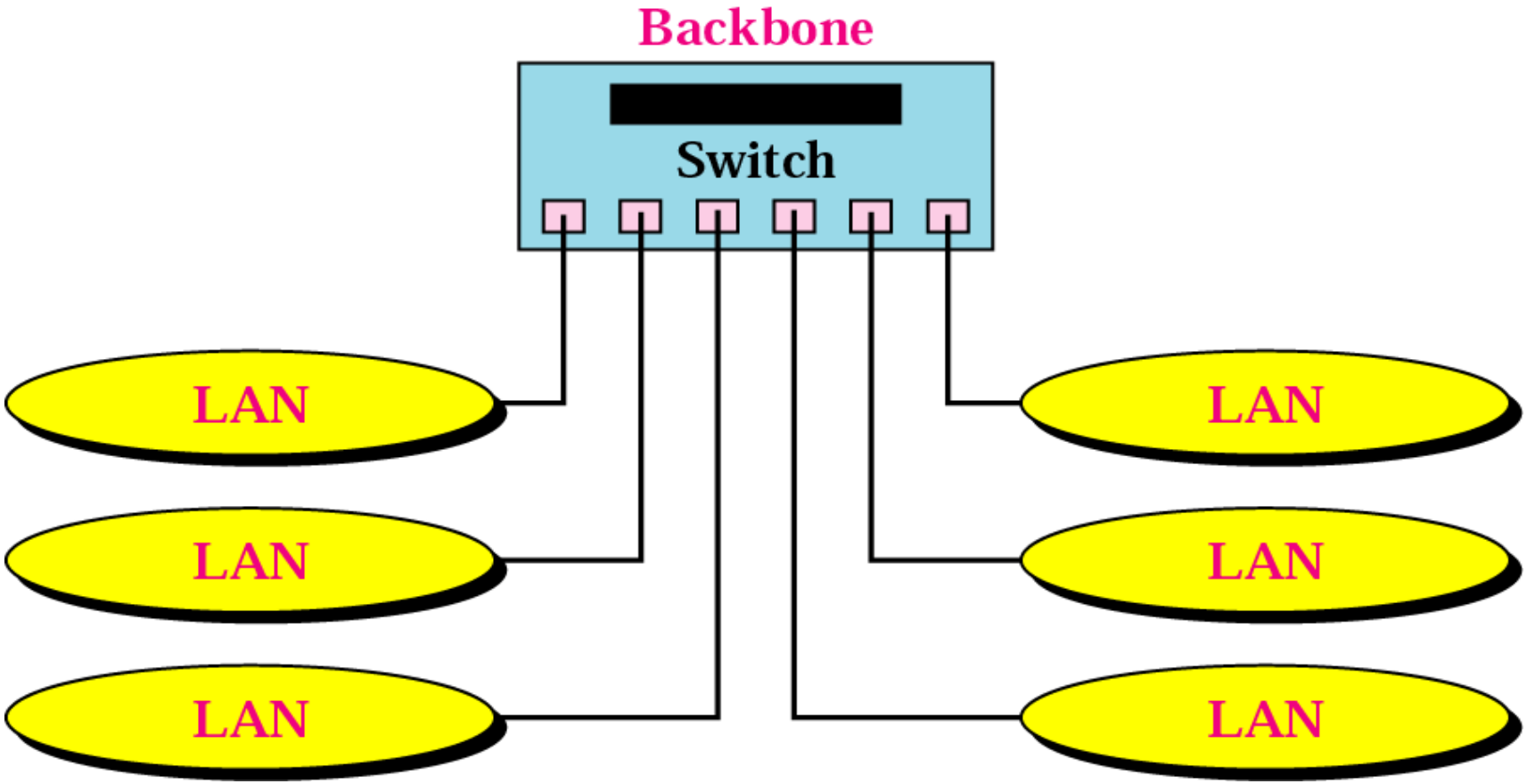
Bus backbone

In a bus backbone, the topology of the backbone is a bus.



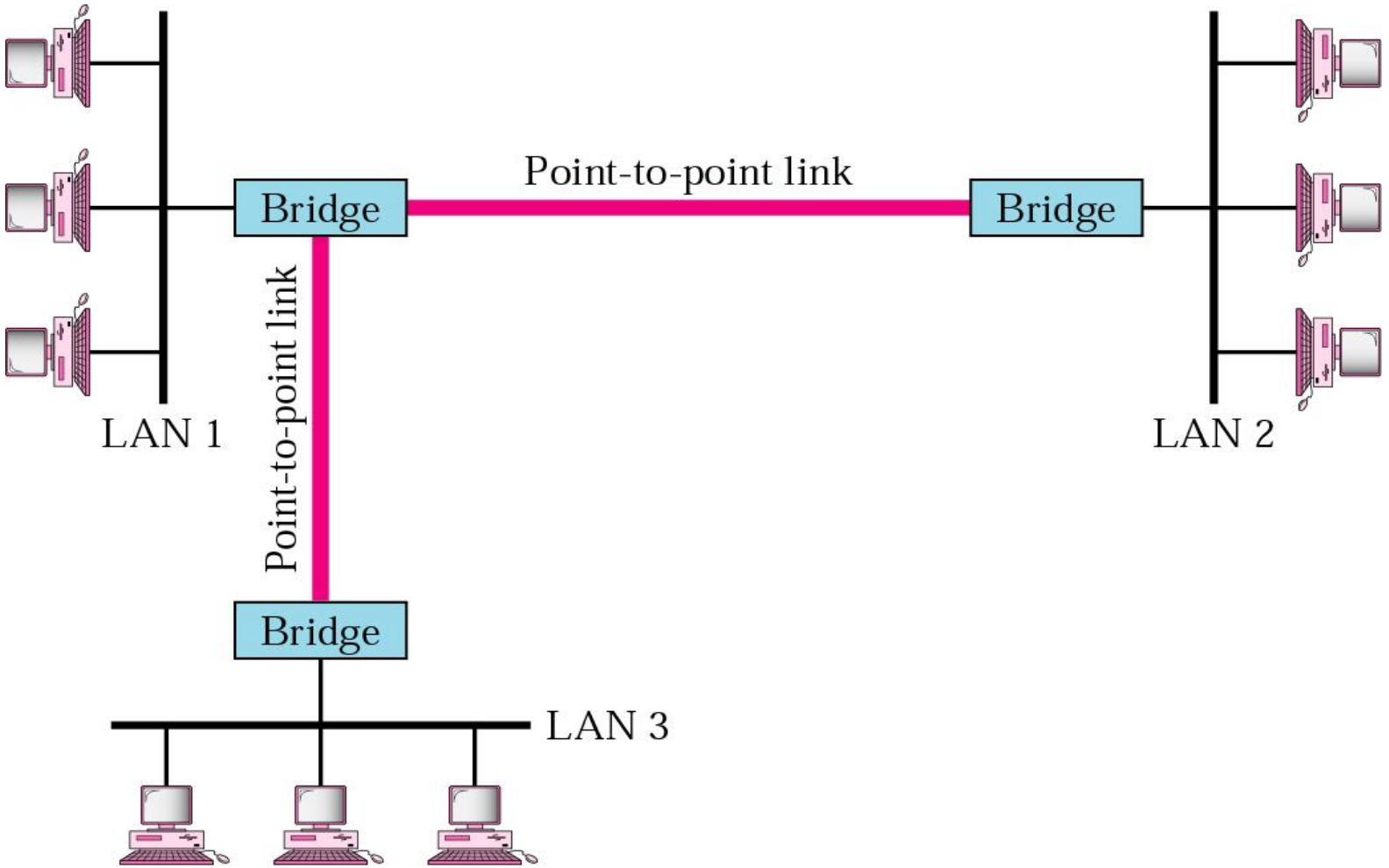
Star backbone

In a star backbone, the topology of the backbone is a star; the backbone is just one switch.



Connecting remote LANs

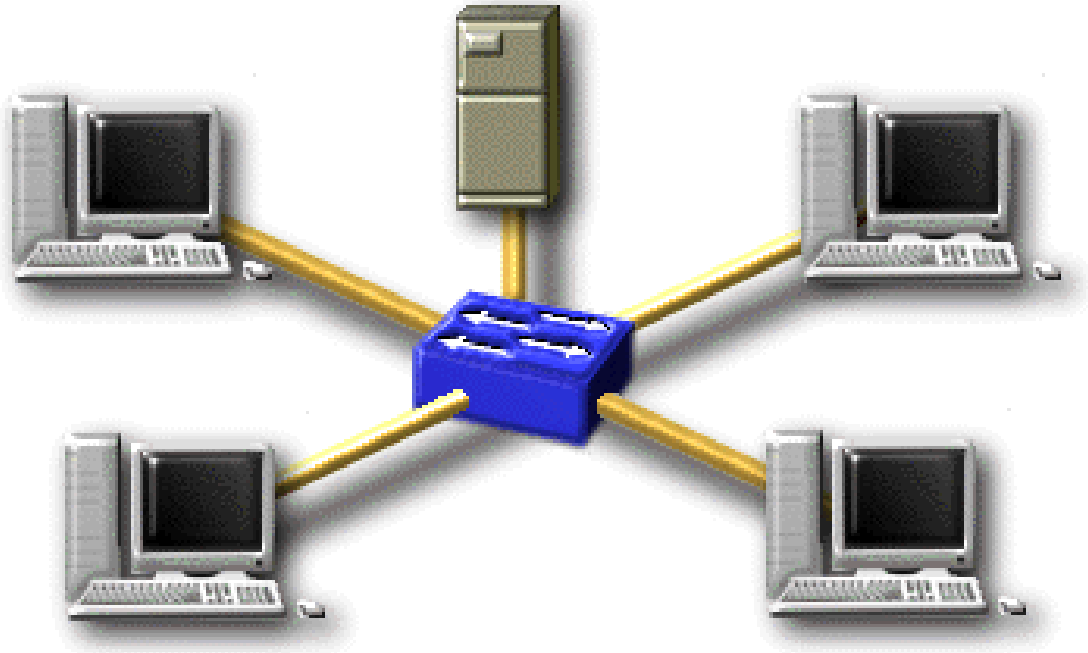
A point-to-point link acts as a LAN in a remote backbone connected by remote bridges.



Type of Switches

- There are :
  - Two-layer switch performs at the physical and data link layer
  - Three-layer switch is used at the network layer.
- A two layer switch is a bridge with many ports , able to allocate a unique port for each station on its own independent entity.
- For eliminate the confusion in general is used:
  - the term bridge for two layer switch and
  - the term switch for three layer switch

Benefits of Switching



- Number of collisions reduced
- Simultaneous, multiple communications
- High-speed uplinks
- Improved network response
- Increased user productivity

Layer 2 Switches

- Central hub acts as switch
- Incoming frame from particular station switched to appropriate output line
- Unused lines can switch other traffic
- More than one station transmitting at a time
- Multiplying capacity of LAN

Layer 2 Switch Benefits

- No change to attached devices to convert bus LAN or hub LAN to switched LAN
- For Ethernet LAN, each device uses Ethernet MAC protocol
- Device has dedicated capacity equal to original LAN
  - Assuming switch has sufficient capacity to keep up with all devices
  - For example if switch can sustain throughput of 20 Mbps, each device appears to have dedicated capacity for either input or output of 10 Mbps
- Layer 2 switch 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 v Bridge

- Layer 2 switch can be viewed as full-duplex hub
- Can incorporate logic to function as multiport bridge
  - Bridge frame handling done in software
- Switch performs address recognition and frame forwarding in hardware
  - Bridge only analyzes and forwards one frame at a time
- Switch has multiple parallel data paths
  - Can handle multiple frames at a time
  - Bridge uses store-and-forward operation
- Switch can have cut-through operation
  - Bridge suffered commercially
    - New installations typically include layer 2 switches with bridge functionality rather than bridges

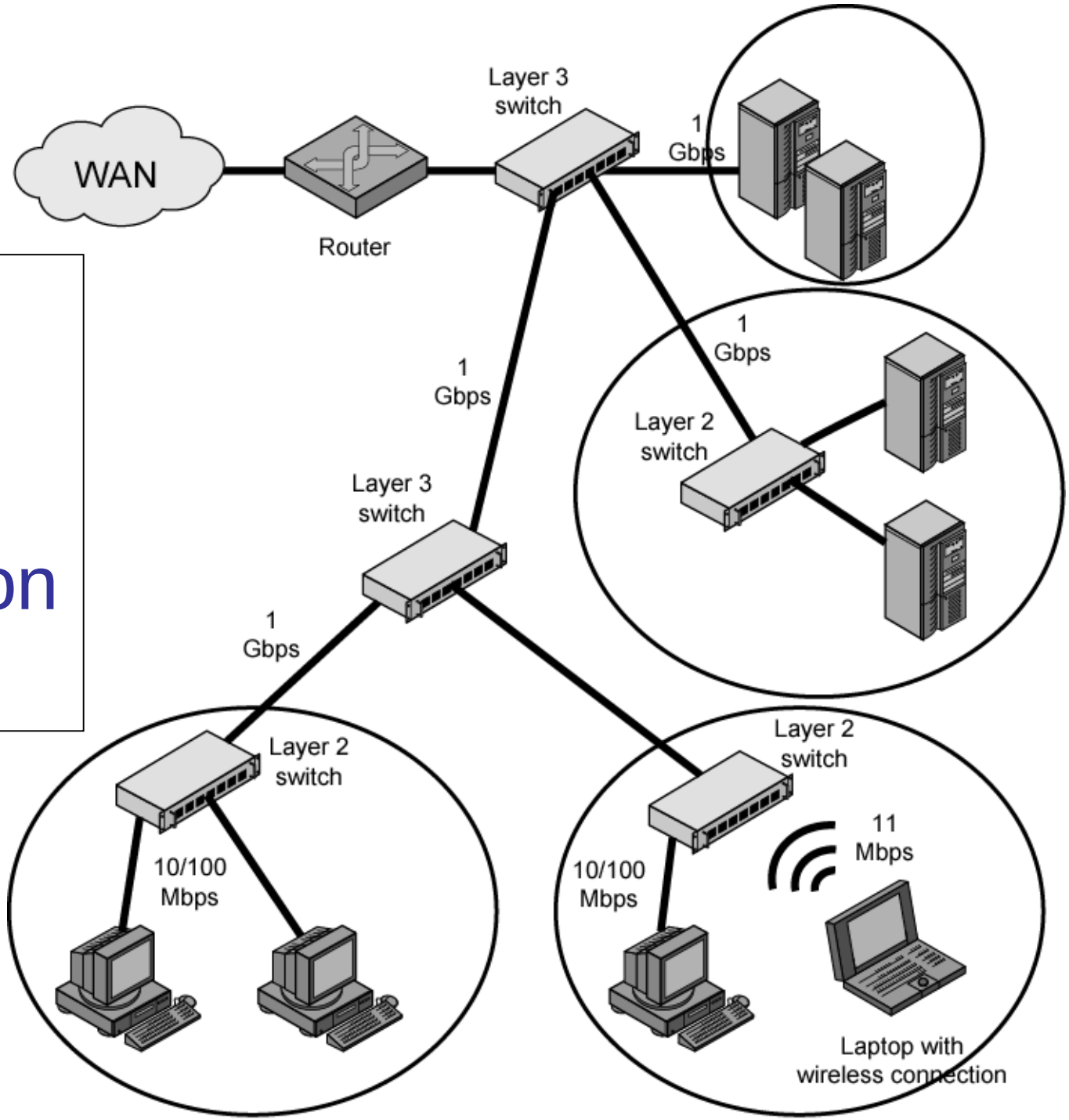
Packet by Packet or Flow Based

- Operates in same way as traditional router
- Order of magnitude increase in performance compared to software-based router
- Flow-based switch tries to enhance performance by identifying flows of IP packets
  - Same source and destination
  - Done by observing ongoing traffic or using a special flow label in packet header (IPv6)
  - Once flow is identified, predefined route can be established

Typical Large LAN Organization

- Thousands to tens of thousands of devices
- Desktop systems links 10 Mbps to 1000 Mbps
  - Into layer 2 switch
- Wireless LAN connectivity available for mobile users
- Layer 3 switches at local network's core
  - Form local backbone
  - Interconnected at 1 Gbps (10 Gbps)
  - Connect to layer 2 switches at 100 Mbps to 1 Gbps
- Servers connect directly to layer 2 or layer 3 switches at 1 Gbps (or 10Gbps)
- Lower-cost software-based router provides WAN connection
- Circles in diagram identify separate LAN subnetworks
- MAC broadcast frame limited to own subnetwork

Typical Large LAN Organization Diagram



Virtual LANs

VLAN is defined as a virtual LAN configured by software , not by physical wiring.

Membership

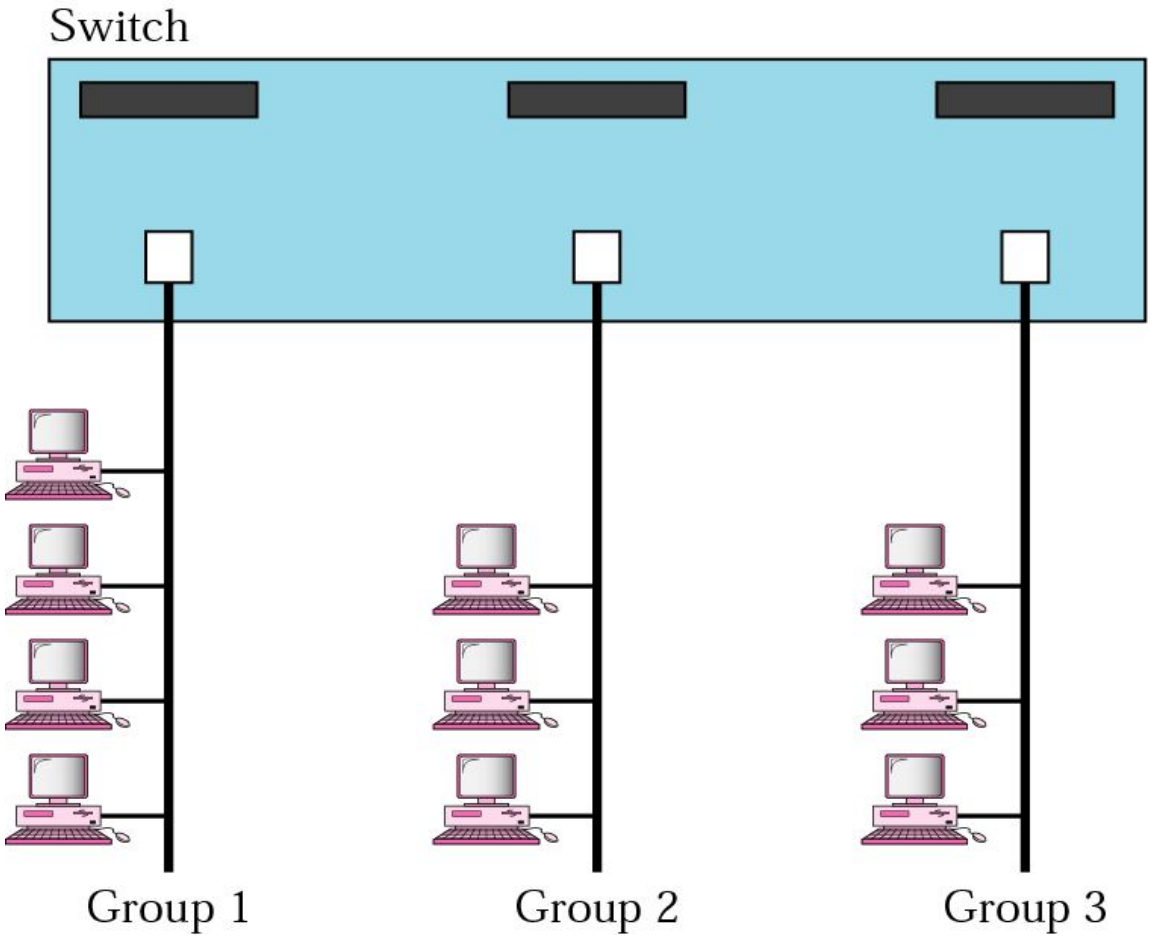
Configuration

IEEE Standard

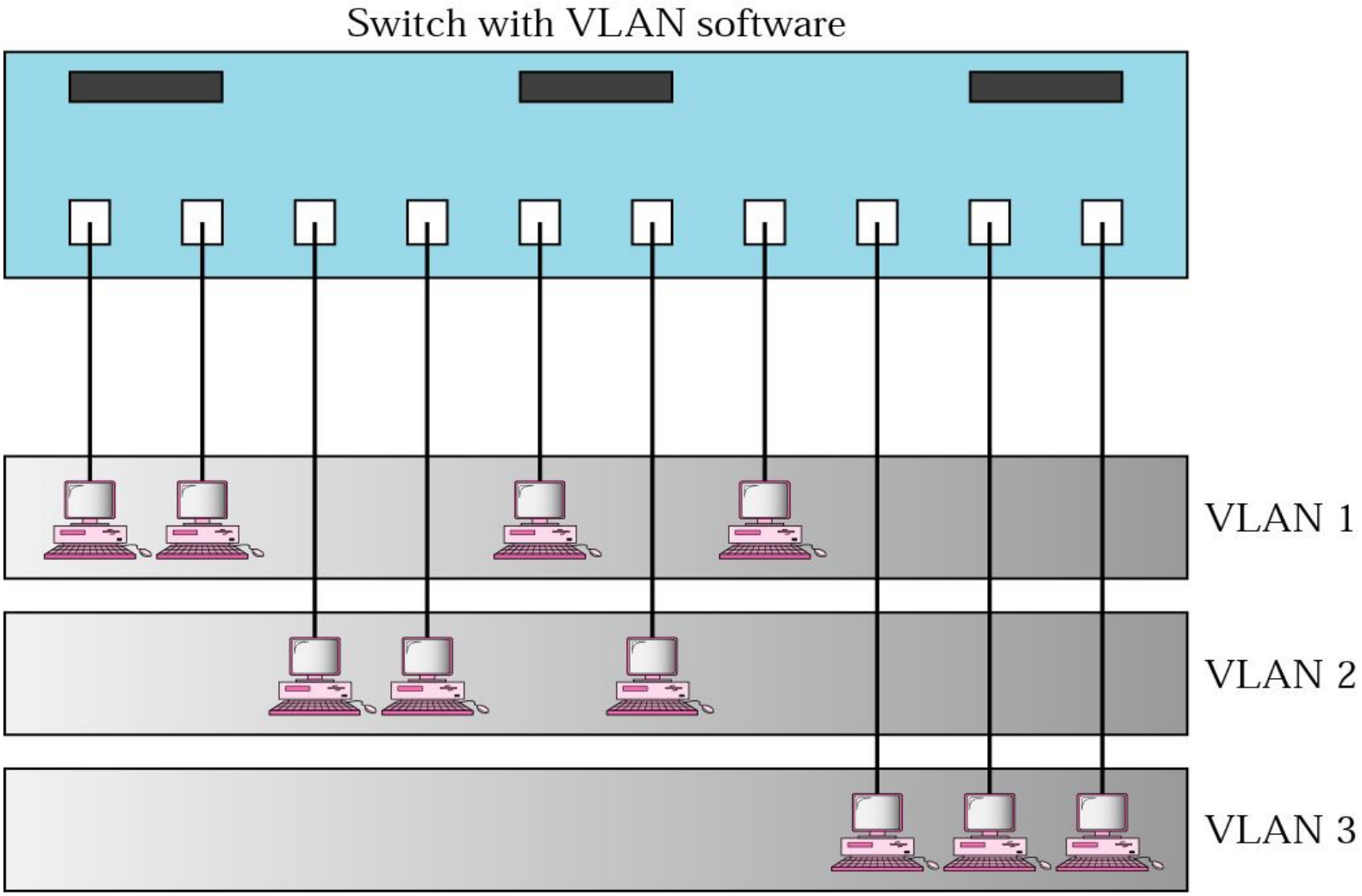
Advantages

A switch connecting three LANs

VLANs create broadcast domains.



A switch using VLAN software



Two switches in a backbone using VLAN software