CONNECTING DEVICES

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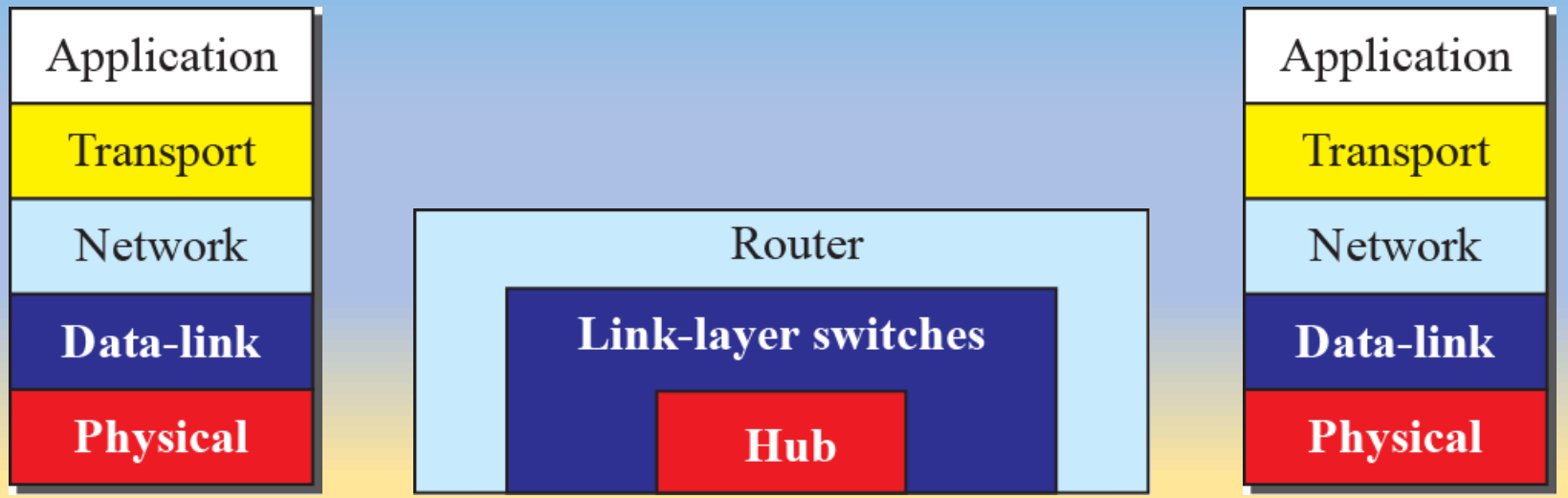
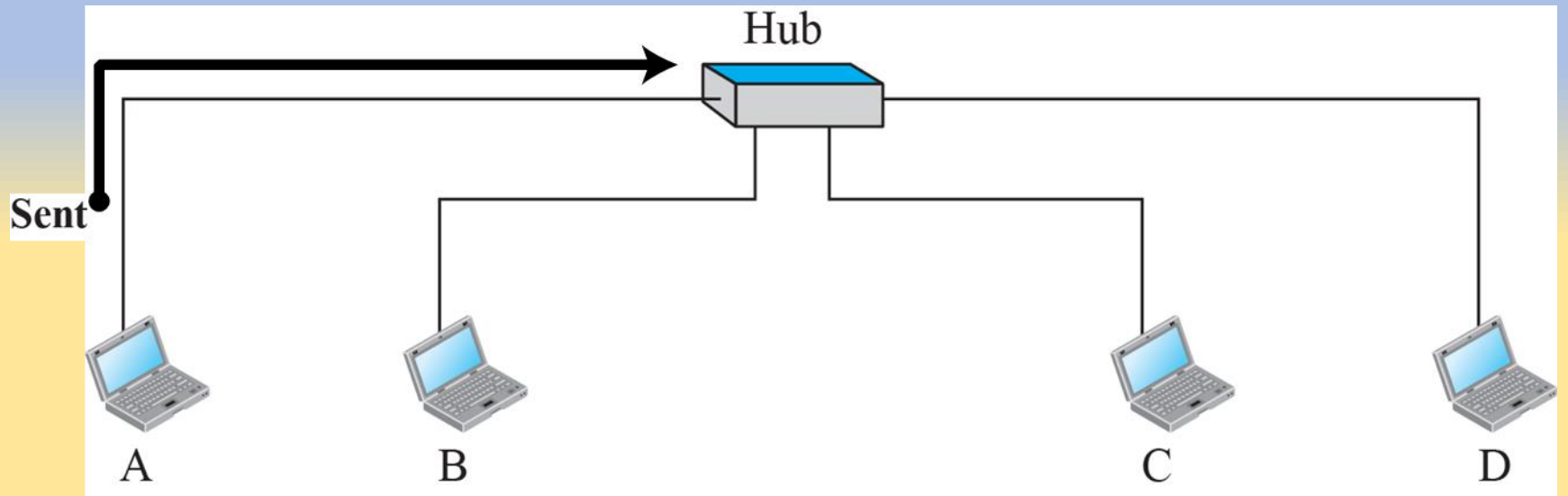
- Connecting devices can operate in different layers of the Internet model.
- three kinds of connecting devices: hubs, link-layer switches, and routers.



Hubs

- Device that operates only in the physical layer.
- A **repeater** receives a signal and, before it becomes too weak or corrupted,
- Today, Ethernet LANs use star topology.
- In a star topology, a repeater is **a multiport device**, often called a *hub,* that can be used to serve as the connecting point and at the same time function as a repeater.



HUBS

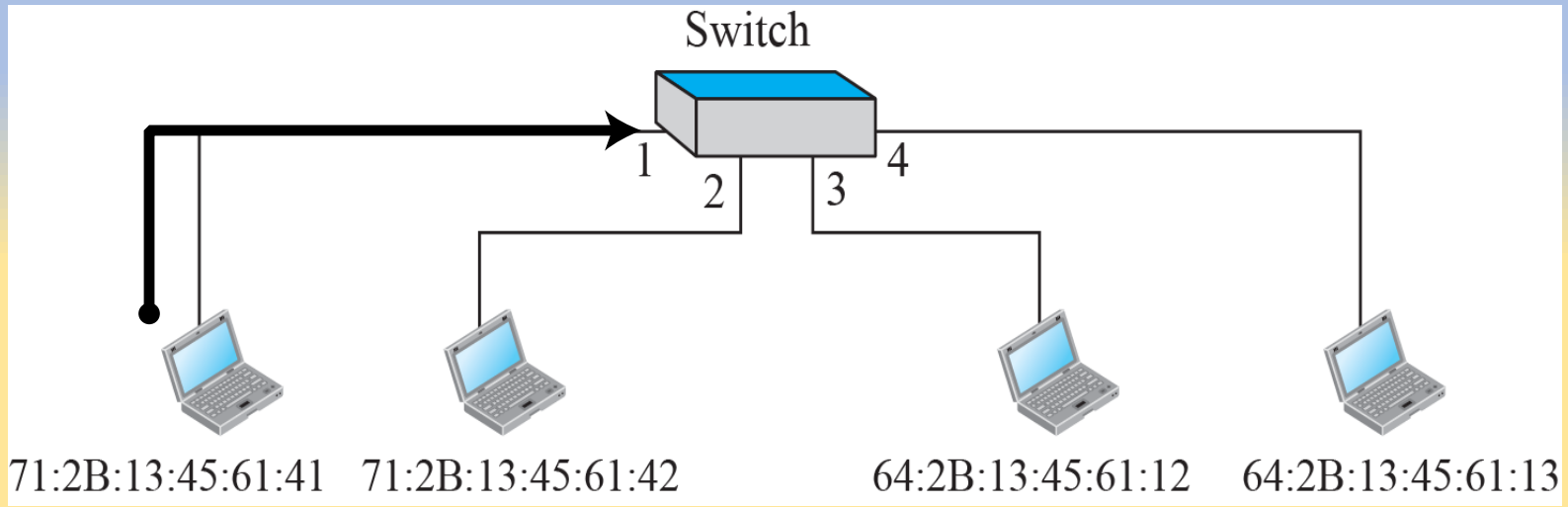
- Does not have the intelligence to find from which port the frame should be sent out.
- They do not have a link-layer address and they do not check the link-layer address of the received frame.
- They just regenerate the corrupted bits and send them out from every port.

Link-Layer Switches

- Operates in both the physical and the data-link layers.
- As a physical-layer device, it regenerates the signal it receives.
- As a link-layer device, the link-layer switch can check the MAC addresses.
- A link-layer switch has **filtering** capability →check the destination address of a frame and can decide from which outgoing port the frame should be sent
- **A link-layer switch has a table used in filtering decisions.**
- **A link-layer switch does not change the link-layer (MAC) addresses in a frame.**

Switching table

Address	Port
71:2B:13:45:61:41	1
71:2B:13:45:61:42	2
64:2B:13:45:61:12	3
64:2B:13:45:61:13	4



Transparent Switches

- a switch in which the stations are completely unaware of the switch's existence.
- If a switch is added or deleted from the system, reconfiguration of the stations is unnecessary.
- Transparent switches must meet three criteria:
  - Frames must be forwarded from one station to another.
  - The forwarding table is automatically made by learning frame movements in the network.
  - Loops in the system must be prevented
- Need a dynamic table that maps addresses to ports automatically.

Learning switch

Address	Port

a. Original

Address	Port
71:2B:13:45:61:41	1

b. After A sends a frame to D

Address	Port
71:2B:13:45:61:41	1
64:2B:13:45:61:13	4

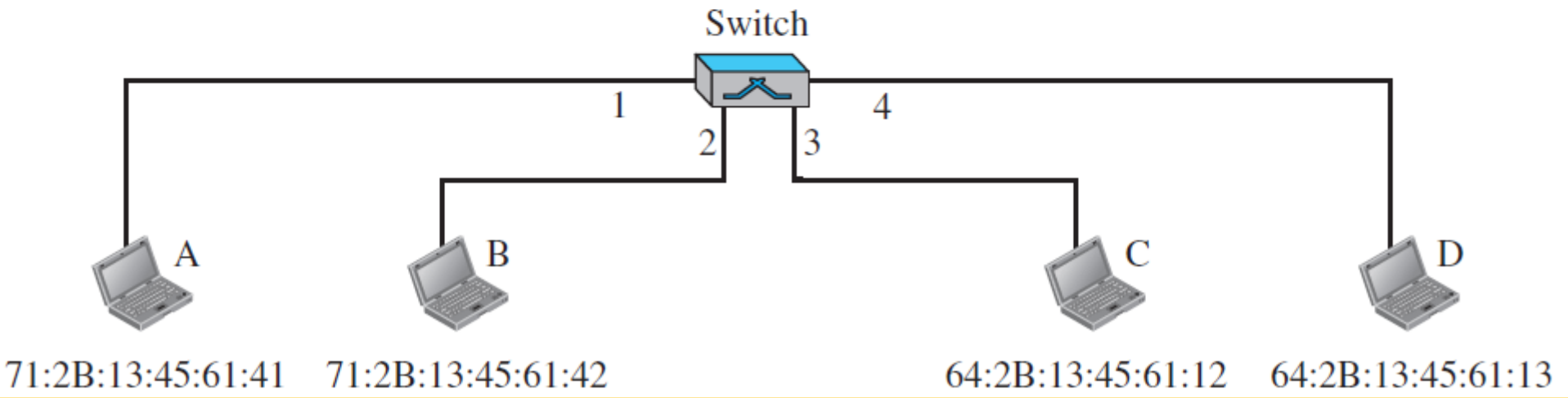
c. After D sends a frame to B

Address	Port
71:2B:13:45:61:41	1
64:2B:13:45:61:13	4
71:2B:13:45:61:42	2

d. After B sends a frame to A

Address	Port
71:2B:13:45:61:41	1
64:2B:13:45:61:13	4
71:2B:13:45:61:42	2
64:2B:13:45:61:12	3

e. After C sends a frame to D

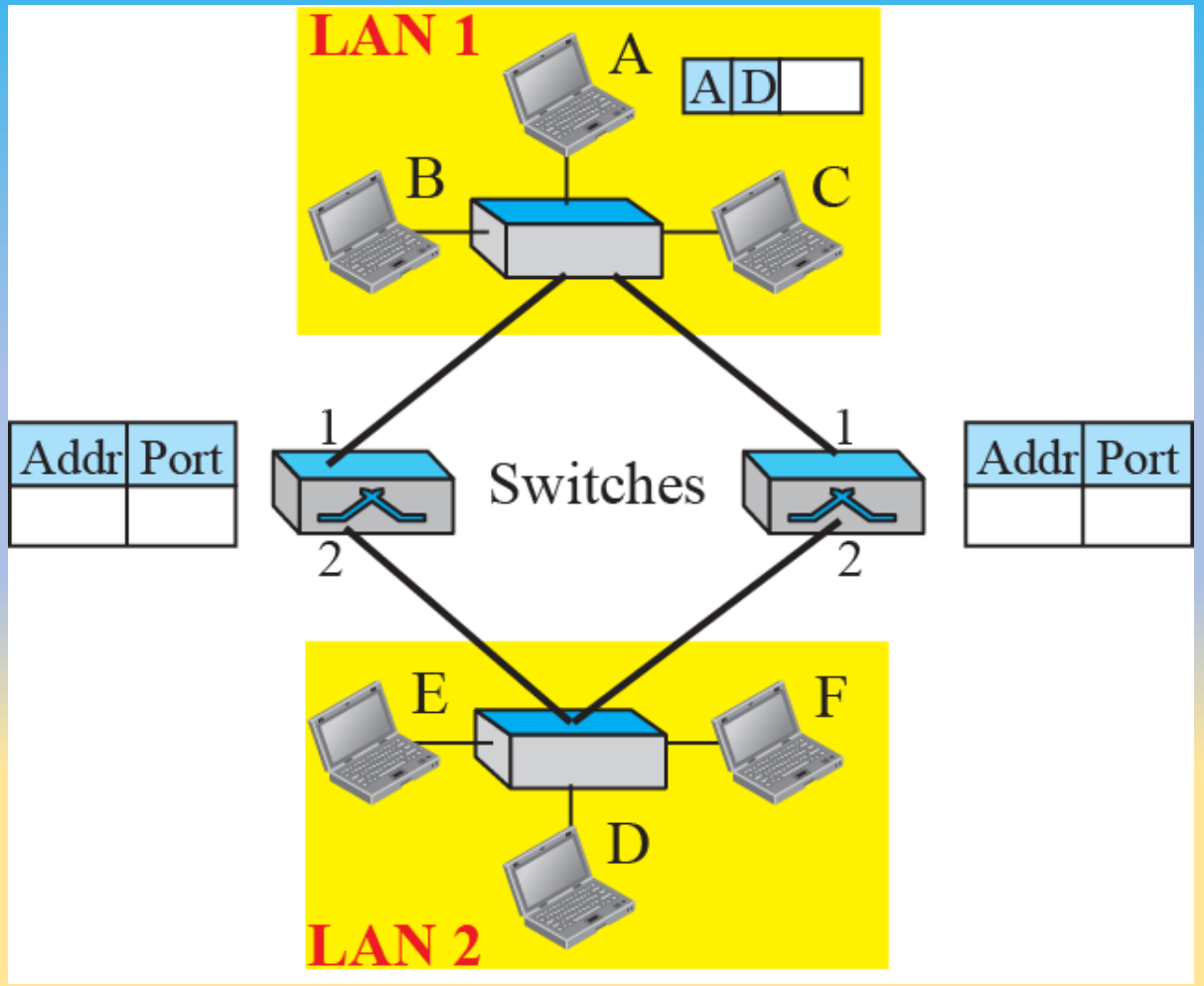


Loop Problem

- Systems administrators, like to have redundant switches to make the system more reliable.
- If a switch fails, another switch takes over until the failed one is repaired or replaced.
- Redundancy can create loops in the system, which is very undesirable.
- Loops can be created only when two or more broadcasting are connected by more than one switch.

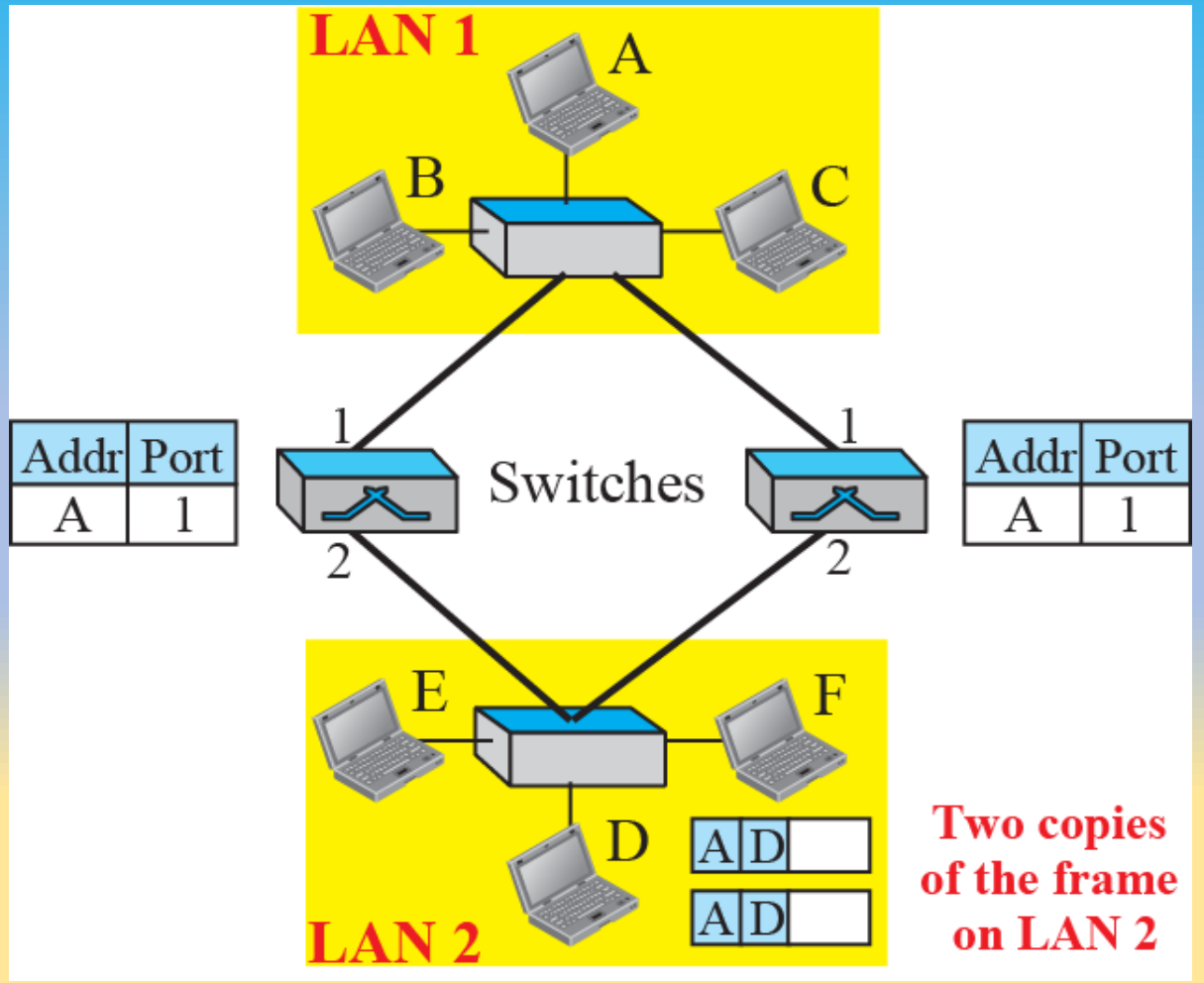
Loop problem in a learning switch

a. Station A sends a frame to station D



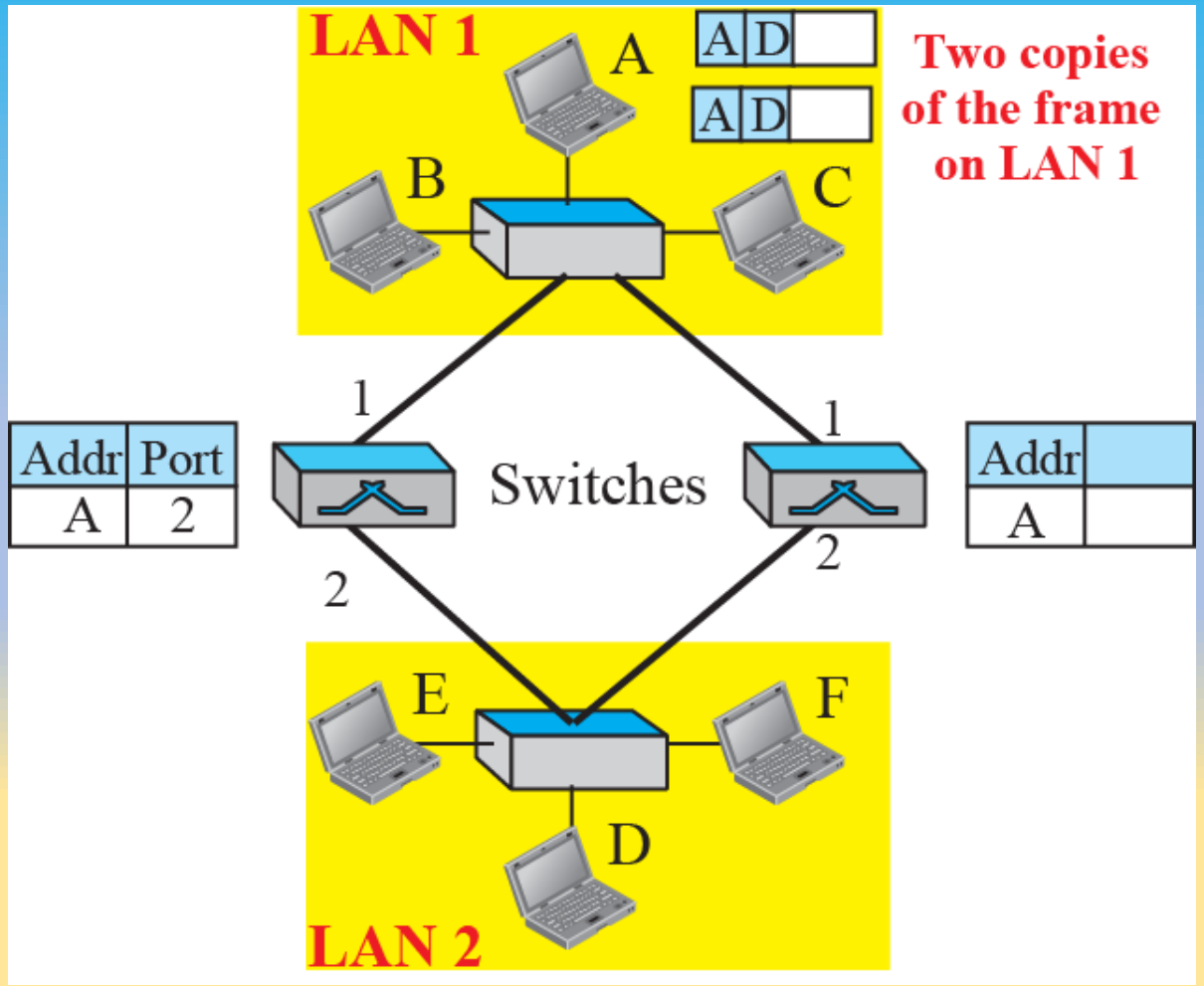
Loop problem in a learning switch

b. Both switches forward the frame



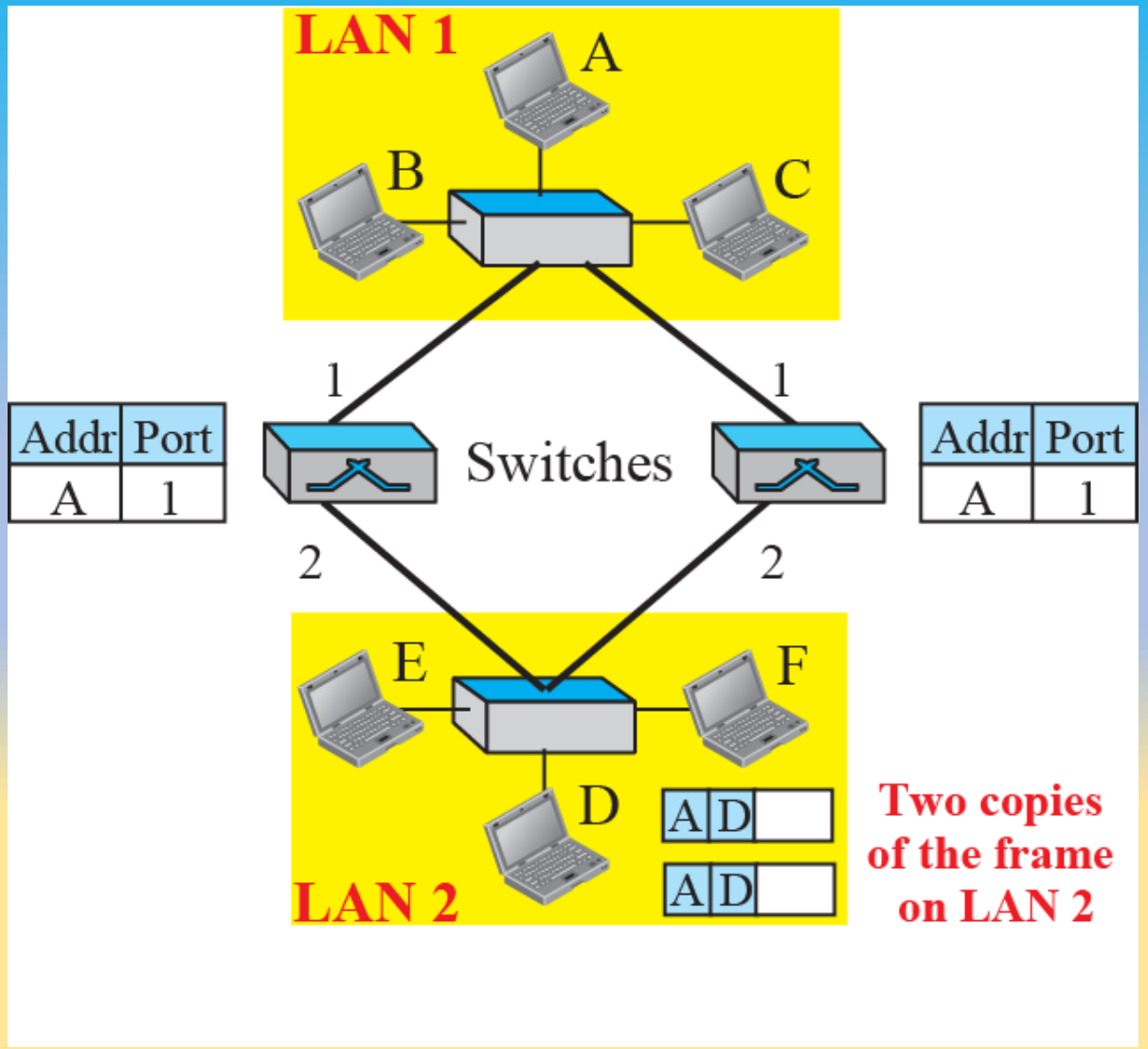
Loop problem in a learning switch

c. Both switches forward the frame



Loop problem in a learning switch

d. Both switches forward the frame



Spanning Tree Algorithm

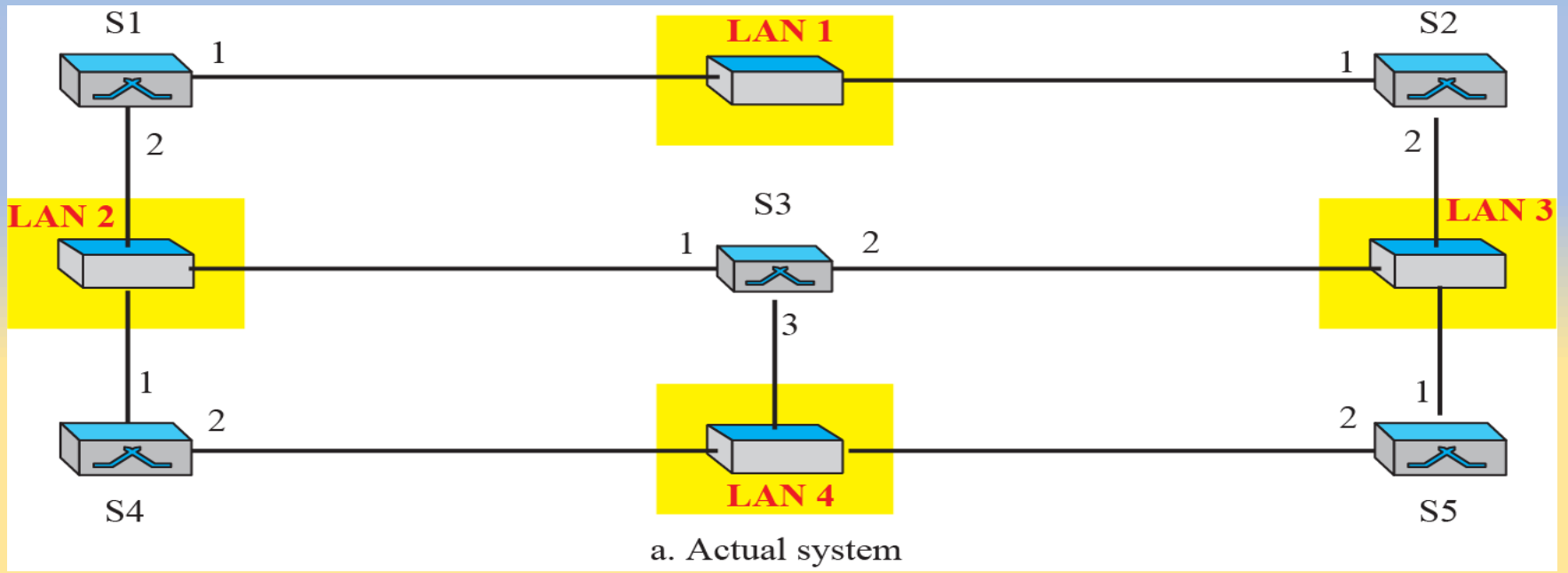
- To solve the looping problem, the IEEE specification requires that switches use the spanning tree algorithm to create a loopless topology.
- In graph theory, a spanning tree is a graph in which there is no loop.
- In a switched LAN, this means creating a topology in which each LAN can be reached from any other LAN through one path only (no loop).
- We cannot change the physical topology of the system but we can create a logical topology
- To find the spanning tree, we need to assign a cost (metric) to each arc → the minimum hops
- Hop count is normally 1 from a switch to the LAN and 0 in the reverse direction.

Spanning Tree Algorithm

The process for finding the spanning tree involves three steps:

1. Every switch has a built-in ID (normally the serial number, which is unique).

- Each switch broadcasts this ID so that all switches know which one has the smallest ID.
- The switch with the smallest ID is selected as the *root* switch (root of the tree).
- We assume that switch S1 has the smallest ID. It is, therefore, selected as the root switch.

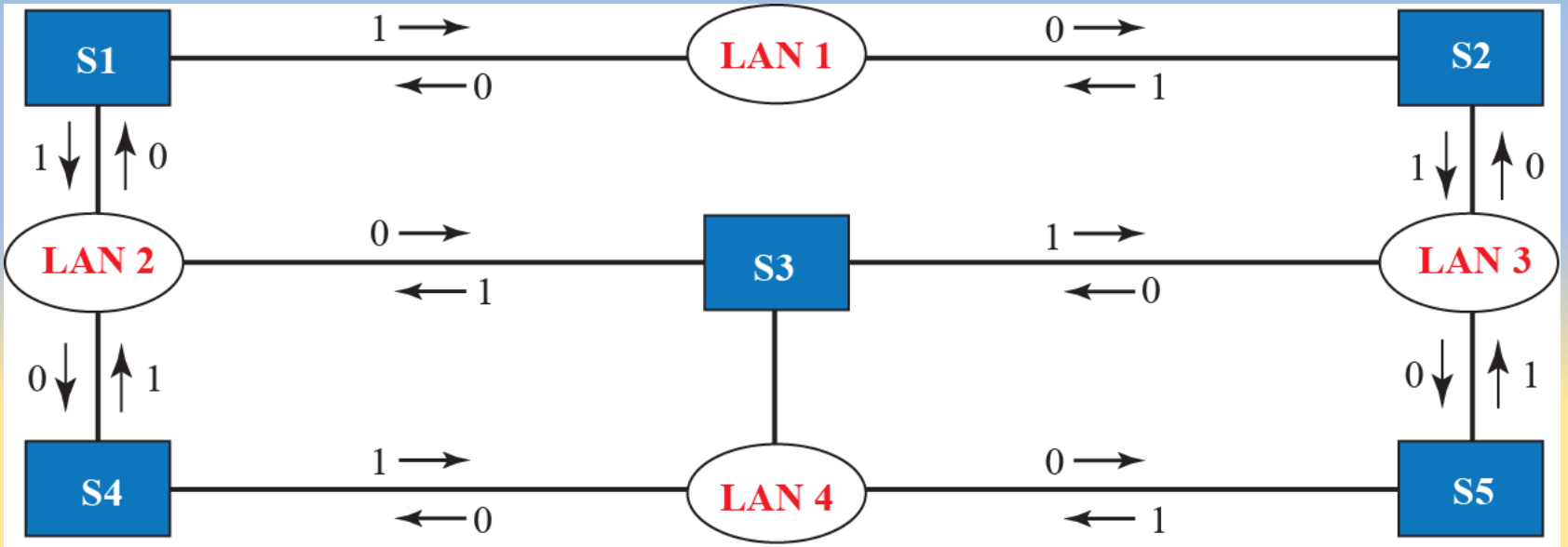


a. Actual system

Spanning Tree Algorithm

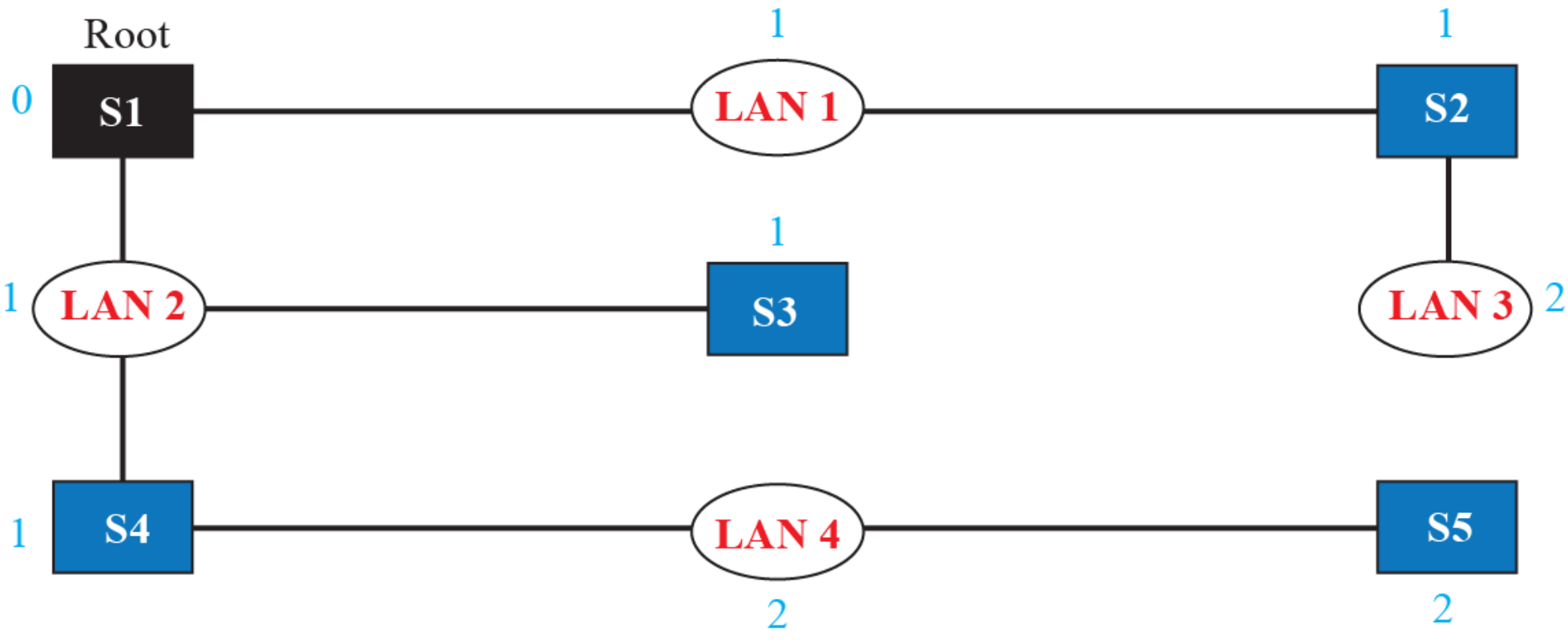
2. The algorithm tries to find the shortest path (a path with the shortest cost) from the root switch to every other switch or LAN.

- The shortest path can be found by examining the total cost from the root switch to the destination. → using the Dijkstra algorithm



b. Graph representation with cost assigned to each arc

Finding the shortest path and the spanning tree for a switch



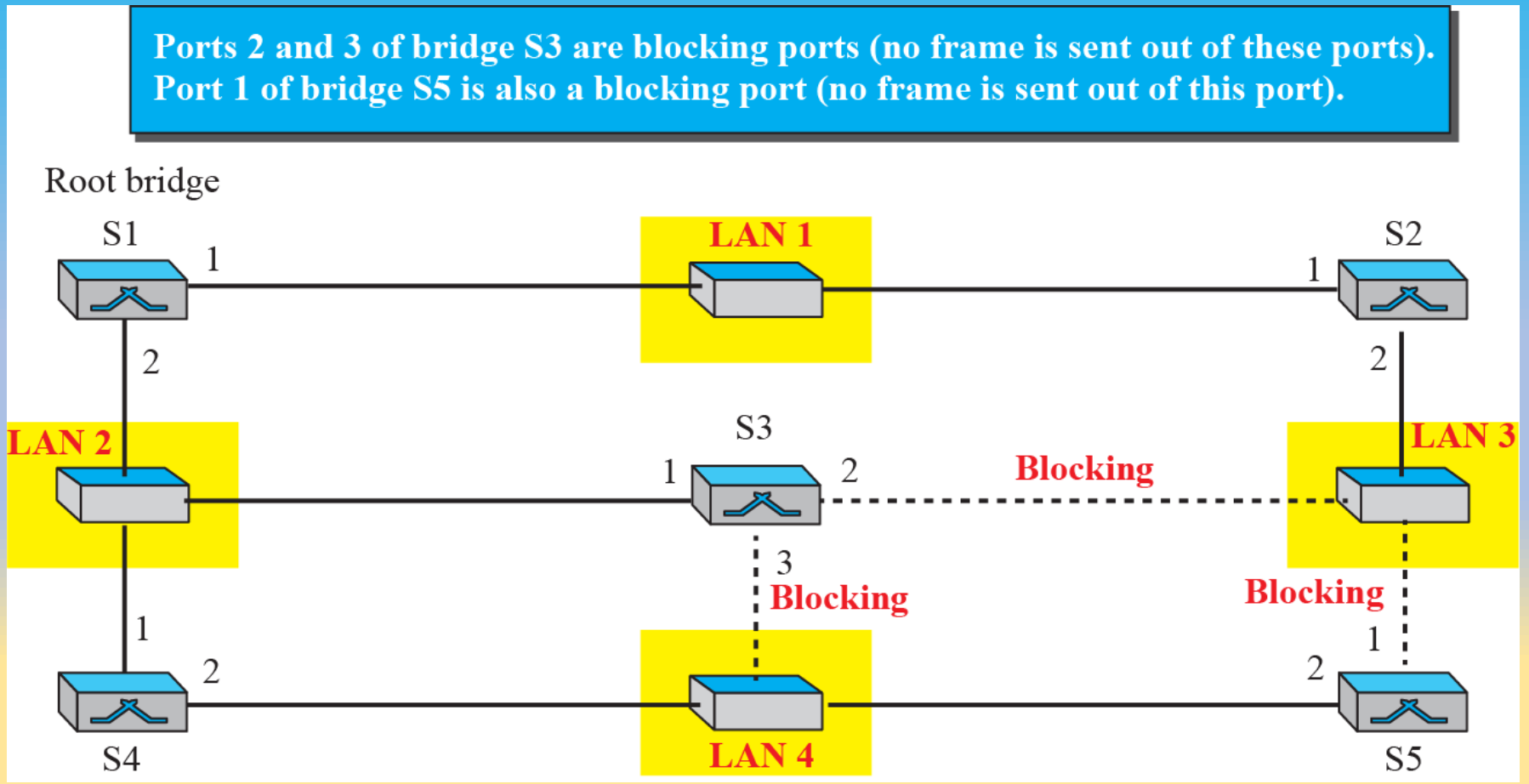
Spanning Tree Algorithm

3. The combination of the shortest paths creates the shortest tree

4. Based on the spanning tree, we mark the ports that are part of it,

- the **forwarding ports,** which forward a frame that the switch receives.
- We also mark those ports that are not part of the spanning tree, the **blocking ports,** which block the frames received by the switch
- Forwarding ports (solid lines) and blocking ports (broken lines).

Forwarding and blocking ports after using spanning tree algorithm



Advantages of Switches

- Collision Elimination
  - a link-layer switch eliminates the collision. This means increasing the average bandwidth available to a host in the network.
  - In a switched LAN, there is no need for carrier sensing and collision detection; each host can transmit at any time.
- Connecting Heterogenous Devices
  - A link-layer switch can connect devices that use different protocols at the physical layer (data rates) and different transmission media.

Routers

- A **router** is a three-layer device; it operates in the physical, data-link, and network layers.
- As a physical-layer device, it regenerates the signal it receives.
- As a link-layer device, the router checks the physical addresses (source and destination) contained in the packet.
- As a network-layer device, a router checks the network-layer addresses.
- A router is an internetworking device; it connects independent networks to form an internetwork

Differences between a router and a repeater or a switch

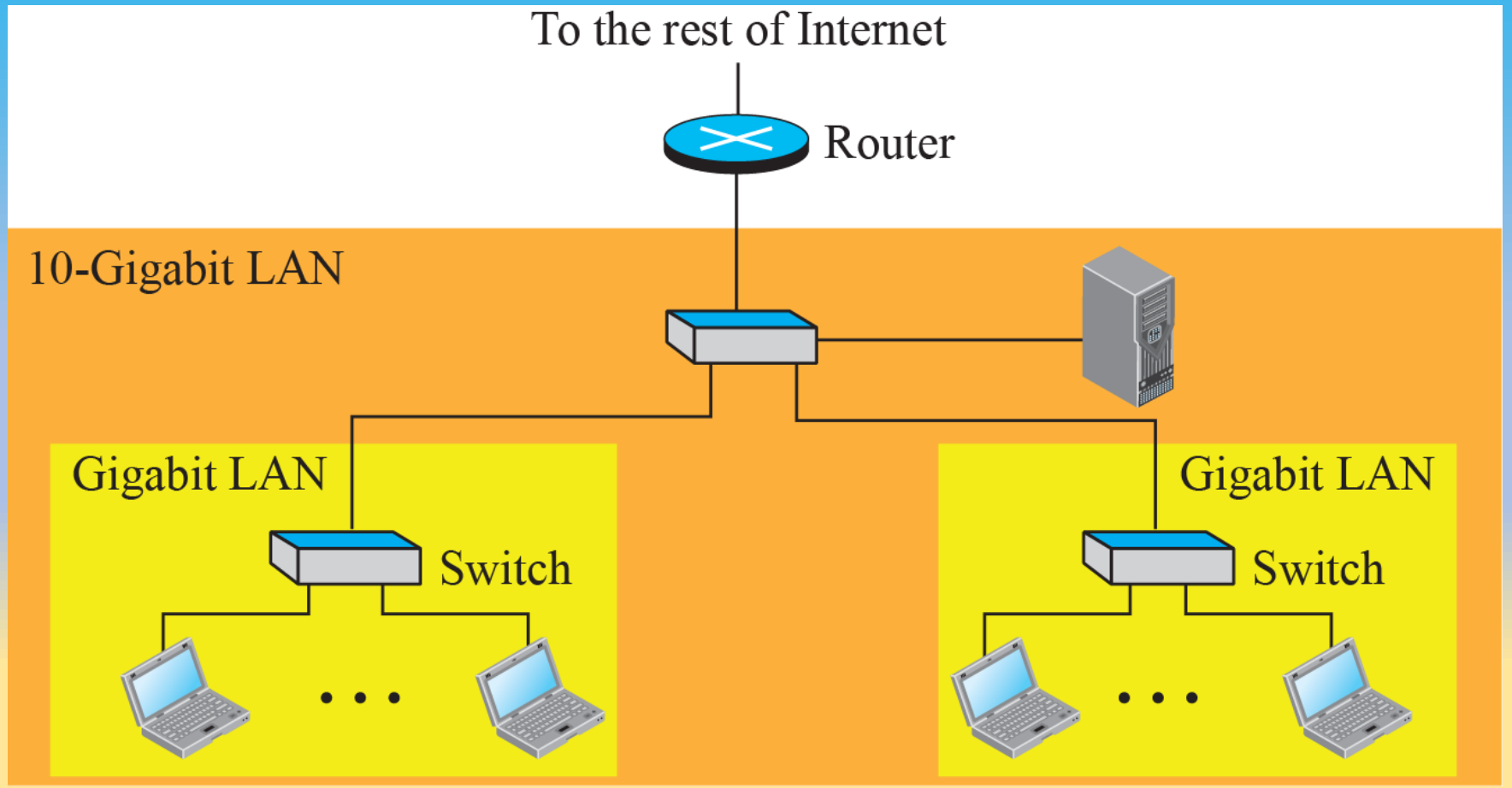
1. A router has a physical and logical (IP) address for each of its interfaces.

2. A router acts only on those packets in which the link-layer destination address matches the address of the interface at which the packet arrives.

3. A router changes the link-layer address of the packet (both source and destination) when it forwards the packet.

- **A router changes the link-layer addresses in a packet.**

Routing example



Summary

- A repeater is a connecting device that operates in the physical layer
- A link-layer switch is a connecting device that operates in the physical and data-link layers of the Internet model.
- A transparent switch can forward and filter frames and automatically build its forwarding table.
- A switch can use the spanning tree algorithm to create a loopless topology

TEST YOUR UNDERSTANDING

- How is a repeater different from an amplifier?
- What is a transparent switch?
- How is a hub related to a repeater?