Chapter 17

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↗ course	🖥 <u>Computer Networks</u>
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Notes

Connecting Devices and Virtual LANs

17.1 Connecting Devices

Connecting devices are essential for connecting hosts to form a network or interconnecting networks to create an internet. These devices operate at different layers of the Internet model: hubs (physical layer), link-layer switches (physical and data-link layers), and routers (network layer).


Figure 17.1 Three categories of connecting devices
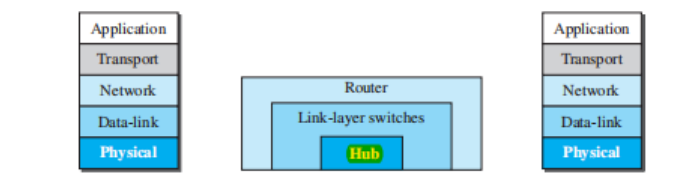
17.1.1 Hubs

- **Function**: Operate in the physical layer, regenerating signals to extend the range of a network.

- **Operation**: Receive signals, regenerate them to remove noise, and broadcast them to all outgoing ports.

- **Characteristics**:

    - No filtering capability.

    - No link-layer addresses.

   - Simply regenerate and broadcast signals without checking addresses.

Figure 17.2 A hub
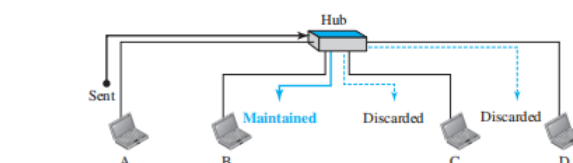
17.1.2 Link-Layer Switches

- **Function**: Operate in both physical and data-link layers, regenerating signals and filtering frames based on MAC addresses.

- **Capabilities**:

  - **Filtering**: Determine the correct outgoing port for each frame based on its destination MAC address.

  - **Transparent Switching**: Operate without requiring changes to the network configuration when added or removed. Comply with IEEE 802.1d standards.

  - **Dynamic Learning**: Build and update a switching table dynamically by inspecting source addresses in frames.

  - **Spanning Tree Algorithm**: Prevent loops by creating a loop-free topology. Use the smallest switch ID as the root and find the shortest path to all switches.

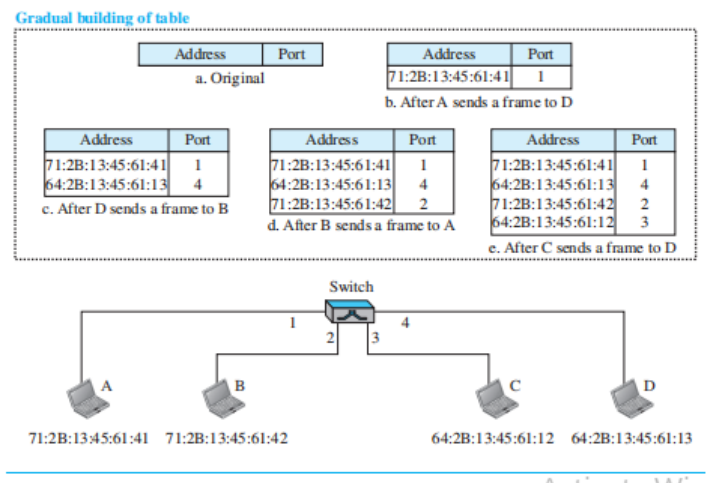**Figure 17.3** Link-layer switch
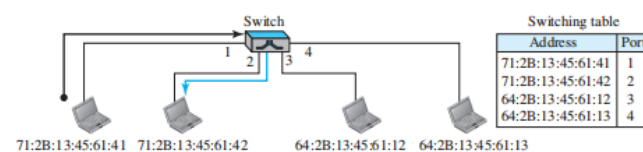
Filtering

- **Difference from Hubs**: Unlike hubs, link-layer switches have filtering capabilities and can direct frames to specific ports.

- **Example**: If a frame for address `71:2B:13:45:61:42` arrives at port 1, the switch checks its table and sends it only through port 2.

Transparent Switches

A **transparent switch** is a switch in which the stations are completely unaware of the switch's existence.

- **Criteria**: Must forward frames, automatically build the forwarding table, and prevent loops.

- **Forwarding and Learning**: Use dynamic tables to map addresses to ports, learning from frame movements.

Figure 17.4   Learning switch

Gradual building of table

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

Switch

A
71:2B:13:45:61:41

B
71:2B:13:45:61:42

C
64:2B:13:45:61:12

D
64:2B:13:45:61:13

Spanning Tree Algorithm

- **Purpose**: Create a loop-free topology by selecting a root switch and finding the shortest path from the root to every other switch.

- **Steps**:

  1. Select the root switch with the smallest ID.

  2. Find the shortest paths from the root to all other switches.

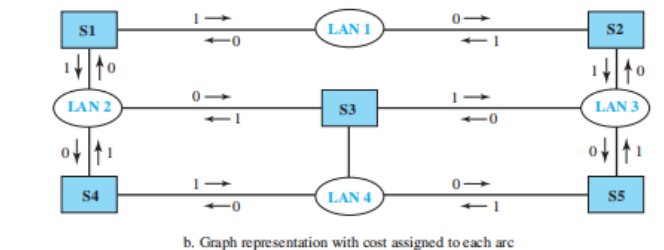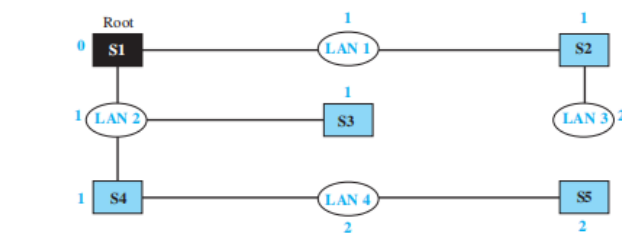 3. Create a spanning tree and mark forwarding and blocking ports to prevent loops.

b. Graph representation with cost assigned to each arc

Figure 17.7   Finding the shortest paths and the spanning tree in a system of switches

Advantages of Switches

1. **Collision Elimination**: No need for carrier sensing and collision detection, allowing hosts to transmit at any time.

2. **Connecting Heterogeneous Devices**: Connect devices with different physical layer protocols and transmission media, as long as the data-link layer frame format is consistent.

Networking Devices: Routers and Virtual LANs

1. Routers

Definition and Function:

- **Multi-layer Device:** Routers operate across the physical, data-link, and network layers.
- **Signal Regeneration:** At the physical layer, routers regenerate signals.
- **Address Checking:** At the data-link layer, routers check physical addresses (MAC) and at the network layer, they check IP addresses.
- **Internetworking:** Routers connect multiple networks, creating an internetwork or internet.

Figure 17.9 Routing example
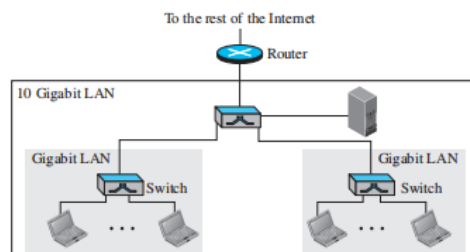
Comparison with Switches and Hubs:

1. **Addressing:**
   - Routers have both physical (MAC) and logical (IP) addresses for each interface.
   - Switches operate primarily at the data-link layer and use MAC addresses.
   - Hubs are basic physical-layer devices that do not use addressing.

2. **Packet Handling:**
   - Routers forward packets based on IP addresses and change the link-layer addresses (MAC addresses) during forwarding.
   - Switches forward packets based on MAC addresses without changing them.
   - Hubs simply regenerate and broadcast signals to all ports.

3. **Networking Scope:**
   - Routers can connect different network segments, facilitating communication between them.
   - Switches connect devices within the same network segment.
   - Hubs connect multiple devices within the same network segment, broadcasting data to all ports.

Example:

- An organization with two buildings, each having a Gigabit Ethernet LAN connected by switches, can use a router to connect these LANs to form a larger network and provide access to the Internet.

2. Virtual LANs (VLANs)

Definition and Purpose:

- **Logical Configuration:** VLANs are configured by software, not by physical wiring, allowing flexible grouping of network devices.

- **Broadcast Domains:** VLANs define broadcast domains, grouping devices logically to receive specific broadcast messages.
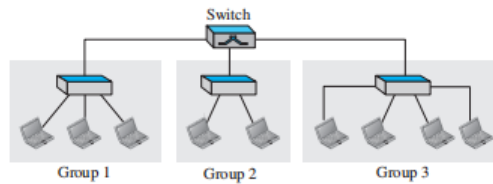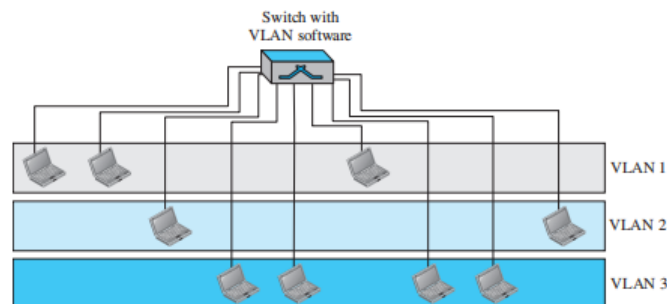
Figure 17.10   A switch connecting three LANs

Figure 17.11   A switch using VLAN software

Advantages:

1. **Cost and Time Reduction:**

   - VLANs reduce the need for physical reconfiguration when moving devices between groups, saving time and cost.

2. **Virtual Work Groups:**

   - They allow the creation of virtual workgroups irrespective of physical locations, useful in environments like university campuses.

3. **Security:**

   - VLANs enhance security by ensuring broadcast messages are only received by devices within the same VLAN.

Configuration Methods:

1. **Manual Configuration:**

   - Network administrators manually assign devices to VLANs using VLAN software.

2. **Automatic Configuration:**

   - Devices are automatically assigned to VLANs based on predefined criteria (e.g., project numbers).

3. **Semiautomatic Configuration:**

   - Initial assignment is manual, but subsequent changes are automatic.

Membership Criteria:

- **Interface Numbers:** Devices connected to specific switch ports.

- **MAC Addresses:** Specific devices based on their unique MAC addresses.

- **IP Addresses:** Devices with specific IP addresses.

- **Multicast IP Addresses:** Grouping based on multicast IP addresses.

- **Combination:** Using a mix of these criteria.

Communication Between Switches:

1. **Table Maintenance:**

   - Switches maintain and periodically update tables recording device memberships.

2. **Frame Tagging:**

   - An extra header is added to frames indicating the destination VLAN.

3. **Time-Division Multiplexing (TDM):**

   - The connection between switches is divided into channels for different VLANs.

IEEE Standard 802.1Q:

- Defines the format for frame tagging and allows multi-vendor VLAN configurations, promoting interoperability.

Summary Comparison: Routers vs. VLANs

Aspect	Routers	VLANs
Layer of Operation	Physical, Data-Link, Network	Data-Link
Address Handling	Changes MAC and IP addresses	Uses MAC/IP addresses based on configuration
Main Function	Connects multiple networks	Creates logical networks within a physical network
Configuration	Hardware-based	Software-based
Security	Enhanced by network segmentation	Enhanced by logical segmentation
Flexibility	Limited by physical interfaces	High flexibility with software configuration