Lab Practical #02: Network Devices - Differences and Working Principles

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Aim/Objective

To understand the differences between various network devices (Hub, Switch, Router, Gateway) and study their working principles in computer networks.

Theory

Network devices are hardware components that facilitate communication between different network segments. Each device operates at specific layers of the OSI model and serves distinct purposes in network infrastructure.

Procedure

1. Differences Between Network Devices

a) Hub vs. Switch

- **Hub:**
  - Operates at Layer 1 (Physical Layer) of the OSI model.
  - Broadcasts all incoming data to all connected devices, regardless of the intended recipient.
  - Creates a single collision domain, leading to inefficient network traffic and potential collisions.
  - Less intelligent and less expensive.
  - Primarily used in older, smaller, or less complex networks.
- **Switch:**

- Operates at Layer 2 (Data Link Layer) of the OSI model.
- Forwards incoming data only to the specific device for which it is intended, using MAC addresses.
- Creates separate collision domains for each port, reducing collisions and improving network efficiency.
- More intelligent and generally more expensive than hubs.
- Commonly used in modern LANs to connect multiple devices efficiently.

b) Switch vs. Router

- **Switch:**
  - Operates at Layer 2 (Data Link Layer) of the OSI model.
  - Connects devices within the same local area network (LAN).
  - Uses MAC addresses to forward data frames.
  - Manages traffic within a single broadcast domain.
  - Typically has many ports (e.g., 8, 16, 24, 48).
- **Router:**
  - Operates at Layer 3 (Network Layer) of the OSI model.
  - Connects different networks (e.g., LANs to WANs, or different subnets).
  - Uses IP addresses to route data packets between networks.
  - Connects multiple broadcast domains.
  - Typically has fewer ports than a switch (e.g., 2, 4, 8) but can connect to high-speed WAN links.
  - Responsible for forwarding packets between different IP networks.

c) Router vs. Gateway

- **Router:**
  - A device that forwards data packets between computer networks, creating an overlay internetwork.
  - Primarily concerned with routing decisions based on IP addresses.
  - Acts as a central distribution point for packets within a network.
  - Can also function as a gateway if it connects two different types of networks or protocols.
- **Gateway:**
  - A network node that connects two different networks that may use different protocols.
  - Translates protocols between the two networks, allowing communication between them.

- Can be a router, firewall, server, or any device that facilitates data flow between disparate networks.
- Essentially, a router is a *type* of gateway (specifically, a gateway for IP-based networks), but not all gateways are routers.

2. Working of Network Devices

a) Switch

- **Learning MAC Addresses:** When a device sends data through a switch, the switch records the device's MAC address and the port it came from in its MAC address table (CAM table).
- **Frame Forwarding:** When a switch receives a data frame, it examines the destination MAC address. It then looks up this MAC address in its MAC address table.
  - If the destination MAC address is found, the switch forwards the frame only to the specific port connected to the destination device.
  - If the destination MAC address is not found (e.g., for a broadcast or an unknown MAC address), the switch floods the frame out of all ports (except the incoming port) until the destination is learned.
- **Collision Domains:** Each port on a switch creates its own collision domain, meaning devices connected to different ports can transmit simultaneously without collisions, significantly improving network performance.

b) Router

- **Packet Forwarding (Routing):** When a router receives an IP packet, it examines the destination IP address.
- **Routing Table Lookup:** The router consults its routing table, which contains information about network paths, including which interface to use to reach specific network destinations and the "next hop" router (if any).
- **Packet Destination:**
  - If the destination network is directly connected to the router, the router sends the packet to the destination device on that network.
  - If the destination network is not directly connected, the router forwards the packet to the next router in the path (the "next hop") as determined by its routing table.
- **Inter-network Communication:** Routers are crucial for connecting different networks and enabling communication across the internet, making decisions on the best path for data to travel.

c) Gateway

- **Protocol Translation:** The primary function of a gateway is to translate protocols between two different networks. For example, a gateway might translate data from an Ethernet network to a Frame Relay network.
- **Network Entry/Exit Point:** A gateway acts as the entry and exit point for a network, allowing traffic to flow in and out of the network and communicate with external networks.
- **Application Layer Functionality:** While routers primarily operate at the network layer, gateways can operate at any layer of the OSI model, often at the application layer, to perform more complex protocol conversions.
- **Example:** A typical home router acts as a gateway, translating private IP addresses within your home network to a public IP address used on the internet via Network Address Translation (NAT).

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