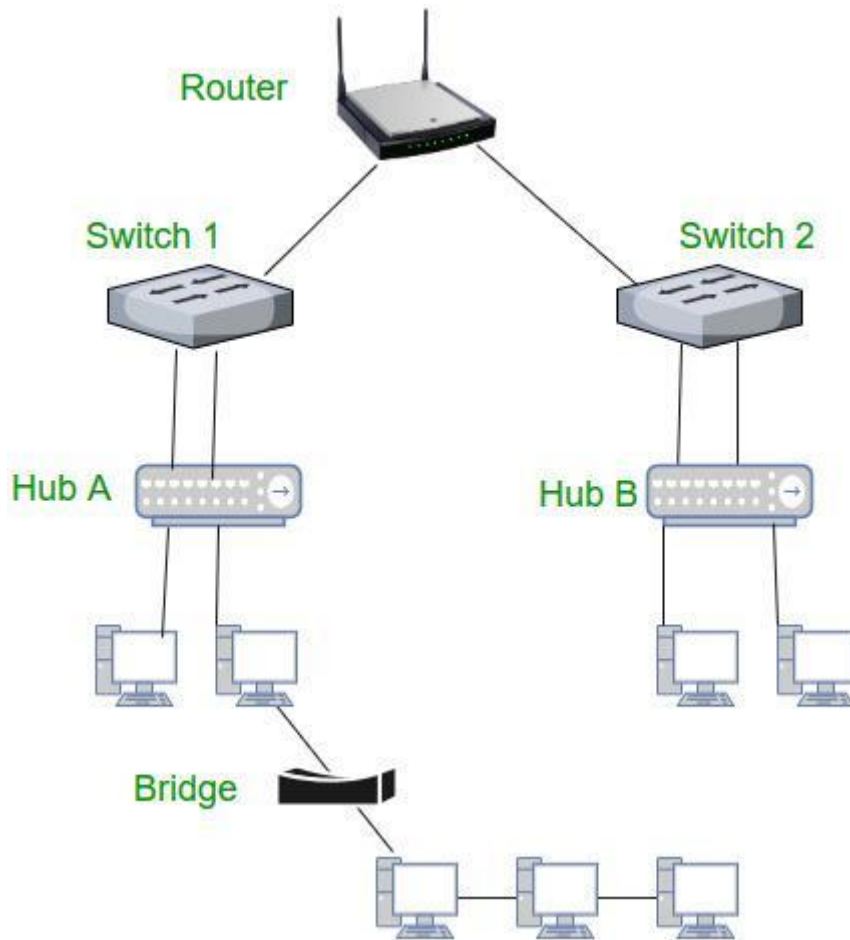**UNIT III**

THE NETWORK LAYER

Routers

A router is a networking device that forwards data packets between different computer networks. It connects multiple packet-switched networks or subnetworks, managing traffic by directing packets to their intended IP addresses. Routers allow multiple devices to share an Internet connection efficiently.

Working of Router:

Routers determine the path for a packet by examining its destination IP address and consulting the routing table, which contains information on network paths. They use a set of rules to identify the most efficient route for each packet.
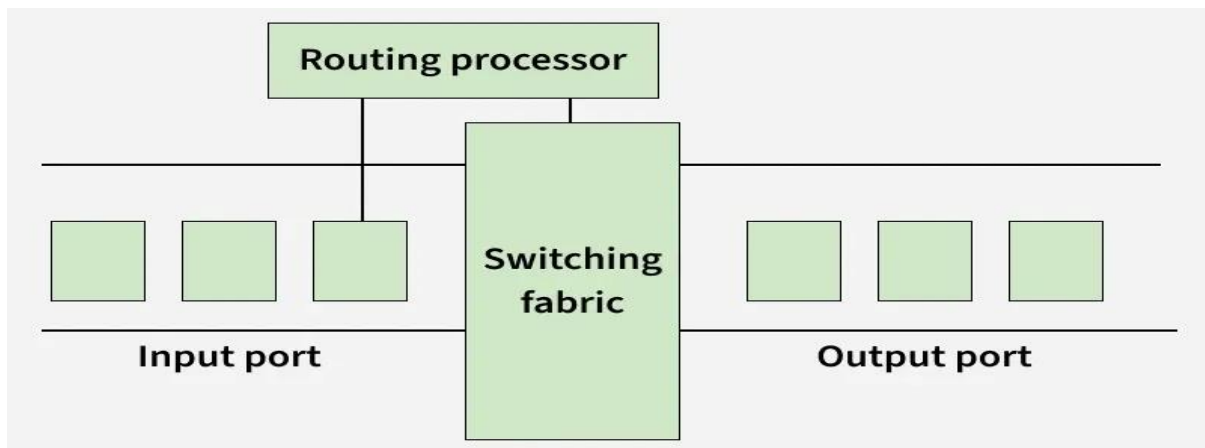- **Static routing:** Configured manually, suitable for small or stable networks.
- **Dynamic routing:** Automatically updated based on network activity, ideal for large or changing networks.

Routers often work with a modem (cable, DSL, or fiber) to enable Internet connectivity

Functions of a Router

- **Forwarding:** Receives packets, examines headers, and forwards them to the correct output port.
- **Routing:** Determines the optimal path for packets using routing tables and algorithms.
- **Network Address Translation (NAT):** Translates private IPs to a public IP for Internet access.
- **Security:** Supports firewalls and other security measures.
- **VPN Connectivity:** Provides secure remote access to networks.
- **Bandwidth Management:** Controls data flow to prevent congestion.
- **Monitoring & Diagnostics:** Tracks traffic and helps troubleshoot network issues.

A typical router consists of:

- **Input Port:** Accepts packets, decapsulates them, and determines forwarding paths.
- **Switching Fabric:** The core of the router connecting input ports to output ports. Can be implemented via:

  Memory switching: CPU copies packets to output ports.
  Bus switching: Single bus transfers packets to the correct port.
  Interconnection networks: Complex designs connecting multiple input/output ports.

- **Output Port:** Transmits packets to outgoing links, managing queuing and link-layer functions.
- **Routing Processor:** Executes routing protocols and algorithms, maintaining the forwarding table.

Common Routing Protocols

- **Open Shortest Path First (OSPF):** Determines the optimal path across networks.
- **Border Gateway Protocol (BGP):** Shares routing information between edge routers.
- **Interior Gateway Routing Protocol (IGRP):** Exchanges routing info within autonomous networks.
- **Enhanced IGRP (EIGRP):** Requests routing paths from neighbors if unknown.
- **Exterior Gateway Protocol (EGP):** Shares routing data between internet hosts.

Applications of Routers

- Connect remote servers, networks, and devices globally.
- Support wired and wireless communication, including high-speed data transfer.
- Used by ISPs to transmit audio, video, image, and email efficiently.
- Implement access control, enabling selective resource usage.

Types of Routers

1. **Broadband Routers:** Connect computers to the Internet and share the connection.
2. **Wireless Routers:** Create Wi-Fi networks in homes or offices.
3. **Wired Routers:** Connect multiple devices via Ethernet cables, common in schools and offices.
4. **Edge Routers:** Located at network boundaries, distributing packets to and from ISPs.
5. **Core Routers:** Operate within networks, handling heavy data traffic.
6. **Virtual Routers:** Software-based routers implemented on virtual machines for flexibility and scalability.
7. **Portable Routers:** Small devices creating private Wi-Fi for mobility.

Security Challenges in Routers

- **Vulnerability Exploits:** Firmware flaws can be exploited by attackers; regular updates are necessary.
- **DDoS Attacks:** Distributed Denial-of-Service attacks can overload routers.
- **Default Admin Credentials:** Weak or unchanged credentials can allow unauthorized access.

Packet forwarding

- **Receiving and inspecting:** When a router receives a data packet, it reads the destination IP address in the packet's header.

- **Consulting the routing table:** The router looks up the destination address in its internal routing table, which contains information about available paths to different networks.

- **Forwarding the packet:** Based on the routing table, the router forwards the packet to the appropriate next-hop router or directly to the destination host on one of its connected networks.

- **Handling layer-2 information:** Before sending the packet to the next device, the router constructs a new Layer 2 header with the correct information to ensure it can be properly transmitted to the next hop.

Routing

- **Building the routing table:** Routers use routing protocols, such as OSPF or BGP, to dynamically build and maintain their routing tables.

- **Calculating the best path:** These protocols enable routers to learn about various network paths and select the most efficient one based on metrics like hop count or bandwidth.

- **Adapting to network changes:** Routing protocols allow routers to adapt to changes in the network topology, ensuring packets can still be delivered even if a path becomes unavailable.

- **Implementing policies:** Routers can also make forwarding decisions based on other criteria, such as the source address, protocol type, or application, for tasks like security or quality of service (QoS).