Week 5 Revision Notes

Week 5 - Routing: Static and Dynamic Routing

1. Introduction to Routing

- **What is Routing?**
  - **Routing** is the process of selecting the best path to send data packets from a source to a destination across networks.
  - Routers are the primary devices used for routing, working at the **Network Layer (Layer 3)** of the OSI model.
- **How Routing Works**:
  - Each packet passes through multiple routers, which forward it closer to the destination based on routing tables.
  - Routing tables in routers store information about possible paths to reach various network destinations.

2. Routers and Routing Process

- **Router Functions**:
  - Routers connect separate networks and ensure data packets find the optimal path.
  - They do not forward broadcast frames, limiting unnecessary data transmission.
- **Router Interfaces**:
  - Routers must have at least two interfaces (ports) to connect and forward packets between networks.
- **Routing Steps**:
  1. **De-encapsulation**: Strips the Layer 2 frame header to expose the Layer 3 packet.
  2. **Path Selection**: Looks up the best path in the routing table based on the destination IP address.
  3. **Encapsulation and Forwarding**: Encapsulates the packet in a new Layer 2 frame and sends it out via the selected interface.
- **Routing Table Basics**:
  - Routing tables contain **destination networks**, **next-hop information**, **metrics** (costs), and **timestamps**.
  - **Hop Count**: The number of routers a packet passes through, helping to identify shorter paths.

3. Types of Routing

- **Static Routing**:
  - Manually configured by network administrators.
  - **Advantages**:
    - Simple and predictable for small, stable networks.
    - Low overhead; does not require extra resources for dynamic updates.
  - **Disadvantages**:
    - Not scalable for large or dynamic networks.
    - If a route fails, there's no automatic rerouting.
  - **Common Use Cases**:
    - Small networks with few routers.
    - Hub-and-spoke topologies where each branch has a single path to the central hub.
- **Dynamic Routing**:
  - Routers automatically learn routes by exchanging information.
  - **Advantages**:
    - Automatically adapts to network changes and reroutes traffic if needed.
    - Suitable for larger, more complex networks.
  - **Disadvantages**:
    - Requires more processing power, memory, and bandwidth for updates.
  - **Components**:
    - **Initialization**: Routers identify directly connected networks.
    - **Sharing and Updating**: Routers exchange route information and update tables periodically or on-demand.

4. Routing Protocols

- **Static vs. Dynamic Protocols**:
  - Static routes are fixed manually, while dynamic protocols allow routers to discover and update routes automatically.
- **Dynamic Routing Protocol Categories**:
  - **Interior Gateway Protocols (IGP)**: Used within a single organization (e.g., **RIP**, **EIGRP**, **OSPF**).
  - **Exterior Gateway Protocols (EGP)**: Used between organizations (e.g., **BGP**).
- **Distance Vector Algorithm**:
  - **Based on Bellman-Ford Algorithm**:
    - Routers share their entire routing table with neighbors periodically.
    - Each router announces the cost (distance) to reach various networks.

    - **Routing Information Protocol (RIP)**:
        - One of the first Internet protocols, using hop count as a metric and updating every 30 seconds.
- **Link State Algorithm**:
    - **Based on Dijkstra's Algorithm**:
        - Routers share information only about their directly connected links.
        - Calculates the shortest path to each destination.
    - **Open Shortest Path First (OSPF)**:
        - Uses **Hello messages** to establish neighbor relationships and update link states only when changes occur.

5. Key Dynamic Routing Protocols

- **Routing Information Protocol (RIP)**:
    - **Operation**: Periodically shares the entire routing table.
    - **Limitations**: Suitable for small networks, as it uses hop count up to 15, which limits scalability.
- **Open Shortest Path First (OSPF)**:
    - **Operation**: Shares only link-state updates (rather than entire tables), minimizing bandwidth use.
    - **Benefits**:
        - Lowers network overhead, quick convergence, and supports large networks.
    - **Process**:
        1. **Hello Messages**: Routers introduce themselves to neighbors.
        2. **Link-State Packets (LSPs)**: Routers share only link information with neighbors.
        3. **Shortest Path Calculation**: Each router calculates the best route to each destination.
- **Enhanced Interior Gateway Routing Protocol (EIGRP)**:
    - **Hybrid Protocol**: Combines features of both distance-vector and link-state protocols.
    - **Benefits**: Provides rapid convergence and maintains backups of primary paths.
- **Border Gateway Protocol (BGP)**:
    - **For External Routing**: Manages how packets are routed across the Internet, between different organizations.
    - **Path Vector Protocol**: Tracks the path of networks to prevent routing loops and ensures data takes the best route.

6. Routing Table Structure and Simplification

- **Routing Table Entries**:

    - **Directly Connected Networks**: Networks connected directly to the router’s interface.
    - **Remote Networks**: Reachable only through other routers.
    - **Default Routes**: Used when no other specific route is found in the table (e.g., `0.0.0.0/0`).
- **Maintaining Efficient Routing Tables**:
    - **Route Summarization**: Combines multiple routes into a single entry, reducing table size.
    - **Next Hop**: Specifies where packets should go next.
    - **Default Route**: Acts as a "catch-all" for unspecified destinations, guiding packets to a default path.

7. Summary

Static Routing	Dynamic Routing
Pros: Simple setup, low resource use	**Pros**: Automatically adjusts to changes
Cons: No automatic rerouting, not scalable	**Cons**: Requires more resources, complexity
Best for: Small networks, single exit points	**Best for**: Large or complex networks