Week 6 Revision notes

Week 6 - Routing Concepts and Protocols

1. Introduction to Routing

- **Definition of Routing**:
  - Routing is the process of moving data packets from one network to another, ensuring they reach their correct destination.
  - This is a critical function of the Internet, allowing devices across different networks to communicate.
- **Role of Routers**:
  - **Routers** are devices designed specifically to perform routing. They operate at the **Network Layer (Layer 3)** of the OSI model.
  - Routers connect separate networks and make decisions about the best path for data packets based on their **routing tables**.

2. Basic Routing Process

- **Three Main Steps in Routing**:
  1. **De-encapsulation**:
     - The router removes the data link layer headers and trailers from the incoming packet, revealing the network layer (Layer 3) information.
  2. **Routing Decision**:
     - The router examines the **destination IP address** in the packet and uses its **routing table** to find the best path.
  3. **Re-encapsulation and Forwarding**:
     - The router places the network layer packet in a new data link frame for the next network segment and forwards it through the correct interface.
- **Routing Tables**:
  - Routing tables are essential tools for routers, listing possible paths and helping them decide where to forward packets.
  - **Core Elements in Routing Tables**:
    - **Destination Network**: The network address for packet destinations.
    - **Next Hop**: The address of the next router in the path to the destination.
    - **Metric**: A value that indicates the "cost" of the route (e.g., hop count or delay).
    - **Timestamp**: Shows when the routing information was last updated.

3. Types of Routing

- **Static Routing**:
  - Routes are manually configured by the network administrator.
  - **Advantages**:
    - Simple setup, predictable, and requires less overhead.
    - Effective for small networks with few routers or where paths rarely change.
  - **Disadvantages**:
    - Difficult to manage on large networks.
    - Cannot automatically adapt to network failures.
  - **Best For**:
    - Small networks or networks with a single path to the destination (e.g., hub-and-spoke topologies).
- **Dynamic Routing**:
  - Routers automatically discover and update routes through communication with other routers.
  - **Advantages**:
    - Automatically adapts to changes in network topology, such as new devices or link failures.
    - Ideal for larger, more complex networks.
  - **Disadvantages**:
    - Requires more processing power, memory, and bandwidth.
    - Can be initially more complex to set up.
  - **Process**:
    - **Initialization**: Routers identify directly connected networks.
    - **Information Sharing**: Routers exchange updates about their known routes.
    - **Continuous Updates**: Routers periodically check and adjust routes to ensure the most efficient paths.

4. Key Routing Protocols

- **Static Routing Protocols**:
  - Requires manual input and adjustments by the network administrator. It is typically used when routes are fixed and rarely change.
- **Dynamic Routing Protocols**:
  - Enable routers to discover paths and adjust routes automatically, using specific algorithms to determine the best path.
- **Types of Dynamic Routing Protocols**:

- **Interior Gateway Protocols (IGP)**: Used within a single organization (autonomous system).
  - **Examples**: **RIP (Routing Information Protocol)**, **EIGRP (Enhanced Interior Gateway Routing Protocol)**, **OSPF (Open Shortest Path First)**.
- **Exterior Gateway Protocols (EGP)**: Used between organizations (across autonomous systems).
  - **Example**: **BGP (Border Gateway Protocol)**.

5. Routing Algorithms

- **Distance Vector Algorithm**:
  - Based on the **Bellman-Ford Algorithm**, this method helps routers determine the best path by sharing their distance to each network.
  - **Routing Information Protocol (RIP)**:
    - A simple distance-vector protocol using hop count as a metric, RIP updates routing tables every 30 seconds.
    - **Limitations**: Suitable for smaller networks due to a maximum hop count of 15.
- **Link State Algorithm**:
  - Based on **Dijkstra's Least-Cost Algorithm**, routers determine the shortest path by sharing information only about their directly connected links.
  - **Open Shortest Path First (OSPF)**:
    - OSPF calculates the best path by considering link states and only updates when there are changes.
    - **Process**:
      - Routers announce their presence with **Hello messages**.
      - They then send **Link State Advertisements (LSAs)** containing information about their connected networks.
      - Routers use the LSAs to build a network map and calculate the shortest paths to each destination.
- **Path Vector Algorithm**:
  - Used by **Border Gateway Protocol (BGP)**, which is designed for large-scale inter-network routing.
  - **BGP Characteristics**:
    - Uses AS (Autonomous System) paths rather than just hop counts.
    - Ensures reliable routing between organizations by preventing loops and making route selection decisions based on policies.

6. Routing Table Management

- **Types of Routing Table Entries**:

    - **Directly Connected Networks**: Networks physically connected to the router.
    - **Remote Networks**: Networks reachable through other routers.
    - **Default Routes**: Used as a last resort when there is no specific route for a destination.
- **Routing Table Optimization Techniques**:
    - **Route Summarization**: Combines multiple entries into a single summary route, reducing table size.
    - **Default Routes**: Acts as a catch-all for unspecified destinations, preventing routing tables from growing too large.

7. Comparison of Static and Dynamic Routing

Static Routing	Dynamic Routing
Simple to set up and maintain	Automatically adapts to network changes
Limited to small or stable networks	Suitable for large, complex networks
No automatic rerouting in case of link failure	Can detect and reroute around failed paths
Best for predictable and small environments	Ideal for dynamic, evolving networks

8. Summary of Routing Protocols

- **RIP (Routing Information Protocol)**:
    - Distance-vector protocol, good for small networks, limited by a maximum of 15 hops.
    - **Metric**: Hop count, with periodic updates.
- **EIGRP (Enhanced Interior Gateway Routing Protocol)**:
    - Advanced protocol that balances elements of both distance-vector and link-state protocols.
    - Uses bandwidth and delay metrics, providing quick recovery from network changes.
- **OSPF (Open Shortest Path First)**:
    - Link-state protocol using Dijkstra’s algorithm for efficient routing.
    - Updates only occur with network changes, saving bandwidth and ensuring fast convergence.
- **BGP (Border Gateway Protocol)**:
    - Path vector protocol, essential for internet routing between organizations.
    - Tracks AS paths to prevent loops, enables policy-based routing, and manages routes across multiple organizations.