COMPUTER NETWORK CASE STUDY:

Link State Routing in a University Network

Problem Definition:

The university's network had been facing several challenges due to increased usage and dynamic changes in the network topology. The primary issues included:

1. <u>Slow Response Times:</u> Users reported delays in accessing resources and services, impacting academic and administrative functions.

2. <u>Routing Loops:</u> The Distance Vector Routing (DVR) protocol led to routing loops during network topology changes, which caused packet loss and further degraded performance.

3. <u>Limited Scalability:</u> The existing network infrastructure was becoming strained as new departments and buildings were added, leading to congestion and increased latency.

4. <u>Complexity in Configuration:</u> The network management team found it challenging to make changes and adapt the configuration to the evolving network needs with the DVR approach.

In light of these issues, the university decided to adopt a Link State Routing (LSR) protocol to enhance the reliability and efficiency of their network.

Physical Configuration:

- Network Topology:

  - The network was designed using a **hierarchical star topology**, which allows for efficient traffic management and straightforward scalability. In this topology, core routers serve as the backbone, while distribution routers connect to specific departments or buildings.

- Devices:

  - Core Routers: 4 Cisco 4500 Series routers, positioned at the central data center, equipped with high-speed 10 Gbps connections.

  - Distribution Routers: 8 Cisco 2900 Series routers, strategically placed to connect various departments, each with 1 Gbps uplinks to the core routers.

  - Access Switches: 40 Cisco Catalyst 2960 switches distributed throughout the campus, connected to distribution routers with 100 Mbps links, ensuring connectivity for end-user devices.

- Physical Layout: The physical layout included redundant connections between core and distribution routers to ensure high availability. Each

distribution router connected to two core routers to avoid a single point of failure.

Logical Configuration:

- Routing Protocol: The university opted for OSPF (Open Shortest Path First) as the Link State Routing protocol due to its efficiency and scalability in larger networks.

- OSPF Area Configuration:

  - Backbone Area (Area 0): Comprising all core routers, this area handles the main routing backbone.

  - Area 1: Distribution routers serving the Science department (192.168.1.0/24).

  - Area 2: Distribution routers for the Arts department (192.168.2.0/24).

  - Area 3: Distribution routers for Administration (192.168.3.0/24).

- Network IP Addressing: Each area was allocated a distinct subnet to facilitate efficient routing and management:

  - Core Routers: 192.168.0.0/24

  - Distribution Routers:

    - Science Department: 192.168.1.0/24

    - Arts Department: 192.168.2.0/24

    - Administration: 192.168.3.0/24

- Access Switches:

    - Science Department: 192.168.10.0/24

    - Arts Department: 192.168.20.0/24

    - Administration: 192.168.30.0/24

- OSPF Configuration: Each router was configured with OSPF, defining its area and enabling OSPF on the appropriate interfaces. Here is an example configuration for a distribution router:

  router ospf 1

  network 192.168.1.0 0.0.0.255 area 1

  network 192.168.0.0 0.0.0.255 area 0

Analysis:

Performance Evaluation

1. Routing Efficiency:

   - OSPF utilizes Dijkstra's algorithm to compute the shortest path from the router to all other nodes in the network, leading to more efficient routing compared to Distance Vector Routing, which relies on hop counts.

   - The response times for accessing internal resources improved by approximately 30%, significantly enhancing the user experience.

2. Scalability:

   - OSPF's hierarchical design allows the university to easily add new areas as departments grow or new buildings are constructed. For instance, if a new Engineering department is established, a new area (Area 4) can be easily created without major disruptions.

3. Link-State Advertisement (LSA):

   - Each OSPF router generates LSAs that provide information about the router's interfaces and their states. These advertisements are flooded to all routers in the area, allowing for a complete and synchronized view of the network topology, which minimizes the chances of routing loops.

   - The network's convergence time decreased from several minutes to under 30 seconds following topology changes, thus improving reliability.

4. Traffic Load Balancing:

   - OSPF supports equal-cost multi-path (ECMP) routing, which enables the simultaneous use of multiple paths to a destination. This capability balanced the load effectively across network paths, which further enhanced throughput.

5. Resource Utilization:

   - OSPF proved to be more bandwidth-efficient for routing updates compared to DVR, where updates were sent to all neighbors regardless of the actual topology change. This reduced unnecessary traffic and improved overall resource utilization.

Challenges Encountered:

- Initial Configuration Complexity:

  - The complexity of OSPF's configuration required thorough planning and understanding of network topology. The network team underwent training to ensure proper deployment and management of OSPF.

- Hardware Limitations:

  - Some older devices in the network were not compatible with OSPF, leading to the necessity for hardware upgrades. This added initial costs and required a phased approach to implementation.

- Network Monitoring:

  - With the introduction of OSPF, the university needed to implement monitoring tools to visualize and manage the OSPF topology actively. This required additional software investments and training.

Report

Summary of Findings

The implementation of Link State Routing using OSPF in the university network resulted in significant improvements in performance and scalability. The following key points summarize the findings:

1. Improved Performance: The response time for resource access improved, resulting in higher satisfaction among users.

2. Enhanced Reliability: The reduction in routing loops and quicker convergence times contributed to a more stable network.

3. Scalable Design: The network is now well-positioned to accommodate future growth, making it easier to add new departments and services.

4. Effective Resource Use: OSPF's efficiency reduced unnecessary bandwidth consumption associated with routing updates.

Recommendations:

1. Continuous Monitoring: Implement robust network monitoring tools to observe OSPF metrics such as link utilization, LSA counts, and convergence times to proactively manage performance.

2. Training Programs: Provide ongoing training sessions for the network administration team to deepen their understanding of OSPF and troubleshooting techniques.

3. Plan for Future Upgrades: As network demands grow, continue to evaluate the hardware and software capabilities to ensure they meet future requirements.

4. Documentation Practices: Maintain comprehensive and up-to-date documentation of the network architecture, configurations, and OSPF operations for better management and troubleshooting.

5. Conduct Regular Assessments: Regularly assess the network performance and OSPF configurations to adapt to changing usage patterns and emerging technologies.

Conclusion:

The case study demonstrates that adopting Link State Routing via OSPF in the university network effectively addressed the limitations posed by Distance Vector Routing. The improved performance, scalability, and reliability of the network infrastructure provide a strong foundation for the university to support its educational and administrative needs effectively. By embracing OSPF, the university has positioned itself to adapt to future technological advancements and growth.