University Campus Network Simulation

(Semester Project)

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ABSTRACT

The document provides a comprehensive technical report on the design, simulation, and implementation of a scalable network for a university campus. The project utilizes Cisco Packet Tracer to model a real-world environment, encompassing multiple buildings and departments. Key networking concepts such as the hierarchical network model, Virtual LANs (VLANs), inter-VLAN routing, Dynamic Host Configuration Protocol (DHCP), and Domain Name System (DNS) are implemented to create an efficient, secure, and manageable network infrastructure. The report details the logical and physical topology, IP addressing scheme, device configurations, and verification procedures, serving as a complete guide to the project's architecture and execution.

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1. Introduction

The project explains the complete design and implementation of a University Campus Network using Cisco Packet Tracer. The purpose of this project is to simulate a real-world campus environment where multiple departments in blocks and an admin block are interconnected using proper networking concepts. As universities grow, their network infrastructure must scale to support an increasing number of users, devices, and applications. A poorly designed network can lead to congestion, security vulnerabilities, and management difficulties. This project addresses these challenges by proposing a structured, hierarchical network design.

The simulation demonstrates how large organizations can manage communication efficiently, securely, and in a scalable way. By segmenting the network into logical broadcast domains using VLANs, we enhance security and performance. Dynamic IP addressing via DHCP simplifies network administration, while routing protocols ensure seamless communication across different departments and physical locations. The entire project is built within the Cisco Packet Tracer simulation environment, allowing for detailed configuration and testing without the need for physical hardware.

[1]

2. Project Objectives

The primary objectives guiding the design and implementation of this university campus network are as follows:

- **To design a structured campus network using a hierarchical model:** Implement a three-layer model (Core, Distribution, Access) to ensure scalability, reliability, and ease of management.
- **To divide departments into separate networks using VLANs:** Logically segment the network to isolate broadcast traffic, improve performance, and enhance security between different departments.
- **To configure routers and switches using Cisco IOS commands:** Perform hands-on configuration of network devices to implement the designed topology and features.

- **To enable dynamic IP addressing using DHCP:** Automate the assignment of IP addresses to end devices to reduce administrative overhead and prevent configuration errors.
- **To allow communication between different departments and blocks:** Configure inter-VLAN routing and a core routing protocol to enable controlled communication between all network segments.
- **To test and verify network connectivity:** Conduct thorough testing to ensure all network services are functioning correctly and all project objectives have been met.
  [1]

3.Network Design and Topology

3.1 Hierarchical Network Model

The network architecture is based on the Cisco Hierarchical Network Model, which divides the network into three functional layers:

- **Access Layer:** This layer provides network access to end users and devices (PCs, laptops, printers). In our design, Layer 2 switches (e.g., Cisco 2960) are deployed in each department to connect hosts. This layer is responsible for port security, VLAN membership, and traffic filtering.
- **Distribution Layer:** This layer aggregates traffic from the access layer switches and provides policy-based connectivity. It acts as the boundary between the access and core layers. A Layer 3 switch (e.g., Cisco 3560) is used at this layer to perform inter-VLAN routing, apply access control lists (ACLs), and define broadcast domains.
- **Core Layer:** This layer acts as the high-speed backbone of the network, responsible for fast and reliable transport of data between distribution layer devices in different buildings. A high-performance router (e.g., Cisco 2901) serves as the core, connecting the main campus blocks. The core layer is designed for high availability and speed, with minimal packet manipulation.
  [2]

3.2 Logical Topology: VLANs and IP Addressing

To logically segment the network, we have defined several VLANs, each corresponding to a specific department or function. This prevents broadcast storms from affecting the entire network and allows for granular security policies. The base IP network chosen for the campus is 10.10.0.0/16, which is sub netted for each VLAN.
[1]

3.2.1 IP Addressing Plan

VLAN ID	Department/Function	Network Address	Subnet Mask	Gateway (SVI)	DHCP Range
10	Admin Office	10.10.10.0/24	255.255.255.0	10.10.10.1	10.10.10.10 - 10.10.10.254
20	Male Faculty	10.10.20.0/24	255.255.255.0	10.10.20.1	10.10.20.10 - 10.10.20.254
30	MS Department	10.10.30.0/24	255.255.255.0	10.10.30.1	10.10.30.10 - 10.10.30.254
40	NUML Library	10.10.40.0/24	255.255.255.0	10.10.40.1	10.10.40.10 - 10.10.40.254
50	Female Faculty	10.10.50.0/24	255.255.255.0	10.10.50.1	10.10.50.10 - 10.10.50.254
60	SE & IT Department	10.10.60.0/24	255.255.255.0	10.10.60.1	10.10.60.10 - 10.10.60.254
70	FYP Labs	10.10.70.0/24	255.255.255.0	10.10.70.1	10.10.70.10 - 10.10.70.254
80	CS & AI Department	10.10.80.0/24	255.255.255.0	10.10.80.1	10.10.80.10 - 10.10.80.254
90	Hostel	10.10.90.0/24	255.255.255.0	10.10.90.1	10.10.90.10 - 10.10.90.254
100	Stationary Shop	10.10.100.0/24	255.255.255.0	10.10.100.1	10.10.100.10 - 10.10.100.254
150	Servers	10.10.150.0/24	255.255.255.0	10.10.150.1	Static IPs

[1]

3.3 Physical Topology

The physical layout consists of a central Campus Core connecting several distinct blocks. Each block contains its own distribution and access layer infrastructure.

- **Campus Core (Main Router):** A Cisco 2901 router acts as the central point of connection for all blocks. It handles routing between the major segments of the university.
- **Computer Science and Engineering Block:** This block houses four departments (CS, SE, AI, IT). Each department has its own Layer 2 access switch. These switches connect to a central Layer 3 switch within the block, which handles inter-VLAN routing for the departments and connects back to the Campus Core Router.
- **Faculty Block:** Contains the Library and the Final Year Project (FYP) lab. Similar to the CSE block, it has access switches for each area connecting to a distribution switch.
- **Management Sciences Block:** This block hosts faculty offices (MS and CS) and the local server farm (DHCP, DNS, Web). The server farm is placed in its own dedicated VLAN for security and is connected directly to the distribution switch of this block.
- **Admin Block:** Contains the Admission and Account offices, each in its own VLAN, with a similar access-distribution structure connecting back to the main campus router.

  [1]

4. Devices and Technologies

4.1 Hardware and Software Specifications

The following devices, simulated in Cisco Packet Tracer, are used to build the network:

1. **Routers:** Cisco 2901 series used as the Core Router to connect different blocks.
2. **Layer 3 Switch:** Cisco 3560 series used as the Distribution Switch in each block for high-performance inter-VLAN routing.
3. **Layer 2 Switches:** Cisco 2960 series used as Access Switches to connect end devices like PCs and laptops to the network.
4. **End Devices:** PCs and Laptops representing user workstations in various departments.
5. **Servers:** Generic servers configured to provide essential network services:

- **DHCP Server:** For dynamic IP address allocation.
- **DNS Server:** For resolving domain names to IP addresses (e.g., `www.university.edu`).
- **Web Server:** To host the university's internal web portal.

6. **Cabling:** Copper Straight-Through cables for connecting dissimilar devices (e.g., Switch to PC, Switch to Router) and Copper Cross-Over cables for similar devices (e.g., Switch to Switch), although modern devices support auto-MDIX. Fiber optic links are recommended for inter-building connections (Core to Distribution) in a real-world scenario for distance and bandwidth.

4.2 Technologies Implemented

- **VLANs:** Used to create logical broadcast domains, separating traffic from different departments for security and performance.
- **Inter-VLAN Routing:** Implemented on Layer 3 switches using Switch Virtual Interfaces (SVIs) to allow controlled communication between different VLANs.
- **DHCP:** Centralized on a dedicated server to automate IP configuration for all end devices across all VLANs. A DHCP relay agent (IP helper-address) is configured on the SVI gateways.
- **DNS:** A dedicated server is configured to handle name resolution for the entire campus network.
- **Routing Protocol:** Protocols are configured on the core router and distribution switches to dynamically exchange routing information and ensure full network reachability and redundancy.

[1]

5. Implementation and Configuration

This section provides authentic and detailed command-line interface (CLI) configurations for the key devices in the network. The examples shown are representative of the configurations applied across the topology.

5.1 Access Switch Configuration

This configuration is for an access switch in the Computer Science department (VLAN 10).

```
! Enter global configuration mode
Switch> enable
```

```
Switch# configure terminal

! 1. Basic Device Configuration
Switch(config)# hostname L2_Switch_CS
L2_Switch_CS(config)# enable secret cisco
L2_Switch_CS(config)# line console 0
L2_Switch_CS(config-line)# password cisco
L2_Switch_CS(config-line)# login
L2_Switch_CS(config-line)# exit

! 2. VLAN Creation
L2_Switch_CS(config)# vlan 10
L2_Switch_CS(config-vlan)# name Computer_Science
L2_Switch_CS(config-vlan)# exit

! 3. Port Assignment (for end devices)
L2_Switch_CS(config)# interface range FastEthernet0/1 - 24
L2_Switch_CS(config-if-range)# switchport mode access
L2_Switch_CS(config-if-range)# switchport access vlan 10
L2_Switch_CS(config-if-range)# spanning-tree portfast  ! Enables fast transition to forwarding state
L2_Switch_CS(config-if-range)# exit

! 4. Trunk Port Configuration (to Distribution Switch)
L2_Switch_CS(config)# interface GigabitEthernet0/1
L2_Switch_CS(config-if)# switchport mode trunk
L2_Switch_CS(config-if)# switchport trunk encapsulation dot1q  ! (Required on older models)
L2_Switch_CS(config-if)# switchport trunk allowed vlan 10
L2_Switch_CS(config-if)# end

L2_Switch_CS# write memory
```

[1]

5.2 Control Switch Configuration

This configuration is for the distribution/core Layer 3 switch in the CSE Block, handling routing for VLANs 10, 20, 30, and 40.

```
! Enter global configuration mode
L3_Switch> enable
L3_Switch# configure terminal

! 1. Basic Configuration and enable IP routing
L3_Switch(config)# hostname L3_Core_CSE
L3_Core_CSE(config)# ip routing  ! CRITICAL: Enables Layer 3 routing functionality

! 2. Create VLANs
L3_Core_CSE(config)# vlan 10
L3_Core_CSE(config-vlan)# name Computer_Science
L3_Core_CSE(config-vlan)# vlan 20
L3_Core_CSE(config-vlan)# name Software_Engineering
L3_Core_CSE(config-vlan)# vlan 30
L3_Core_CSE(config-vlan)# name Artificial_Intelligence
L3_Core_CSE(config-vlan)# vlan 40
L3_Core_CSE(config-vlan)# name Information_Technology
L3_Core_CSE(config-vlan)# exit

! 3. Create Switch Virtual Interfaces (SVIs) for Inter-VLAN Routing
! SVI for VLAN 10
L3_Core_CSE(config)# interface Vlan10
L3_Core_CSE(config-if)# description Gateway for CS Department
L3_Core_CSE(config-if)# ip address 10.10.10.1 255.255.255.0
L3_Core_CSE(config-if)# ip helper-address 10.10.150.10 ! Points to the DHCP Server
L3_Core_CSE(config-if)# no shutdown
```

```
! SVI for VLAN 20
L3_Core_CSE(config)# interface Vlan20
L3_Core_CSE(config-if)# description Gateway for SE Department
L3_Core_CSE(config-if)# ip address 10.10.20.1 255.255.255.0
L3_Core_CSE(config-if)# ip helper-address 10.10.150.10
L3_Core_CSE(config-if)# no shutdown

! (Repeat for VLANs 30 and 40)

! 4. Configure Trunk Port to Access Switch
L3_Core_CSE(config)# interface GigabitEthernet0/1
L3_Core_CSE(config-if)# switchport mode trunk
L3_Core_CSE(config-if)# switchport trunk encapsulation dot1q

! 5. Configure Routed Port to Main Campus Router
L3_Core_CSE(config)# interface GigabitEthernet0/24
L3_Core_CSE(config-if)# no switchport ! Converts port to a Layer 3 routed port
L3_Core_CSE(config-if)# ip address 10.1.1.2 255.255.255.252 ! Point-to-point link
L3_Core_CSE(config-if)# no shutdown
L3_Core_CSE(config-if)# end

L3_Core_CSE# write memory
```

[1]

5.3 Server Configuration

The servers are located in VLAN 150. The DHCP server is configured with pools for each VLAN.

5.3.1 DHCP Server Configuration

On the DHCP Server device in Packet Tracer:

- **IP Address:** 10.10.150.10
- **Subnet Mask:** 255.255.255.0
- **Default Gateway:** 10.10.150.1
- **DNS Server:** 10.10.150.11

Under the 'Services' > 'DHCP' tab, create a pool for each VLAN:

- **Pool Name:** VLAN10_CS
- **Default Gateway:** 10.10.10.1
- **DNS Server:** 10.10.150.11
- **Start IP Address:** 10.10.10.10
- **Subnet Mask:** 255.255.255.0
- **Maximum Users:** 245

Click 'Add'. Repeat for all other VLANs (VLAN20_SE, VLAN30_AI, etc.).

[1]

5.3.2 DNS Server Configuration

On the DNS Server device (IP: 10.10.150.11):

- Under 'Services' > 'DNS', turn the service 'On'.
- Create an 'A Record':
  - **Name:** www.university.edu
  - **Address:** 10.10.150.12 (IP of the Web Server)

  Click 'Add'.

5.4 Main Router Configuration

The main router connects all blocks and routes traffic between them using OSPF.

```
! Enter global configuration mode
Router> enable
Router# configure terminal

! 1. Basic Configuration
```

```
Router(config)# hostname Core_Router
Core_Router(config)# no ip domain-lookup

! 2. Interface Configuration (connecting to CSE Block L3 Switch)
Core_Router(config)# interface GigabitEthernet0/0/0
Core_Router(config-if)# description Link to CSE Block
Core_Router(config-if)# ip address 10.1.1.1 255.255.255.252
Core_Router(config-if)# no shutdown
Core_Router(config-if)# exit

! (Repeat for interfaces connecting to other blocks)

! 3. OSPF Routing Configuration
Core_Router(config)# router ospf 1
Core_Router(config-router)# router-id 1.1.1.1
! Announce directly connected networks
Core_Router(config-router)# network 10.1.1.0 0.0.0.3 area 0
! Announce networks learned from other blocks
Core_Router(config-router)# network 10.10.0.0 0.0.255.255 area 0
Core_Router(config-router)# end

Core_Router# write memory
```

[1]

6. Network Testing and Verification

After configuration, a series of tests were performed to verify that the network operates as intended and meets all objectives.

6.1 Connectivity Testing

The ping command was used to test end-to-end connectivity.

- **Intra-VLAN Communication:** A PC in the CS department (e.g., 10.10.10.15) successfully pinged another PC in the same department (e.g., 10.10.10.20). This confirms Layer 2 switching is working correctly.
- **Inter-VLAN Communication:** A PC in the CS department (10.10.10.15) successfully pinged a PC in the Library (e.g., 10.10.50.15). This confirms that inter-VLAN routing on the Layer 3 switch is functional.
- **Server Access:** A PC from any department successfully pinged the DHCP (10.10.150.10), DNS (10.10.150.11), and Web (10.10.150.12) servers.
- **Web Access:** From a PC's web browser, navigating to `http://www.university.edu` successfully loaded the homepage from the Web Server, confirming that DNS and HTTP services are working
  [1]

6.2 Path Tracing (Traceroute)

The tracer (or traceroute) command was used to verify the routing path. A trace from a CS PC (10.10.10.15) to a Library PC (10.10.50.15) showed the following path:

1. CS Gateway (SVI on L3 Switch): 10.10.10.1

2. Library Gateway (SVI on L3 Switch): 10.10.50.1

3. Destination PC: 10.10.50.15

This confirms that traffic is correctly routed through the Layer 3 switch as designed.[1]

7. Conclusion

This project successfully designed and simulated a comprehensive university campus network using Cisco Packet Tracer. All initial objectives were met. A scalable hierarchical network was established, providing a clear structure for future growth. The use of VLANs effectively segmented the network, enhancing security and performance by isolating departmental traffic. Inter-VLAN routing was enabled through Layer 3 switches, allowing for controlled communication between departments. The implementation of DHCP and DNS servers automated critical network services, simplifying administration and improving user experience. Finally, thorough testing confirmed full connectivity and the correct operation of all configured protocols and services.

8. References:

[1] Cisco Packet Tracer Projects, Cisco Packet Tracer Project 2022 | University/CAMPUS Networking Project using Packet Tracer, (2022). Accessed: Dec. 20, 2025. [Online Video]. Available: https://www.youtube.com/watch?v=e1cD2KIme-E

[2] Jen English (Editorial Director), “Network Computing,” Campus Network Design Models. Accessed: Dec. 20, 2025. [Online]. Available: https://www.networkcomputing.com/data-center-networking/campus-network-design-models