East West University

Project Report

Title: Design a full-fledged network for an organization with multiple subnets.

Course Title: Computer Networking

Course Code: CSE 405

Section No: 03

Submitted By

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1. Introduction

1.1. Abstract

This report outlines the design and simulation of a scalable enterprise network for **Apex University**, developed in Cisco Packet Tracer. The network connects eight campuses through OSPF routing, supported by a centralized server farm providing DHCP for dynamic IP allocation, DNS for name resolution, and a web server. Both wired and wireless clients are integrated to reflect real-world usage. The final design ensures seamless connectivity, efficient resource sharing, and reliable scalability across the entire university.

1.2. Project Background

Apex University, is an enterprise like East West University, owns many computers, with a complex network infrastructure. Apart from wired internet access to all the classrooms, labs, employee PCs, library and other administrative and academic wings, the university also provides wireless internet access for every campus. On top of that, the university runs complex networked systems to support several of its business process like admissions, advising, results, eTender, library management, accounts and so on.

2. Purpose and Objectives

2.1. Purpose of the Network

The purpose of this project is to design and implement a unified, scalable, and secure network infrastructure for **Apex University** that supports academic, administrative, and research operations across multiple campuses. The network aims to provide seamless inter-campus communication, centralized service management, and reliable access for both wired and wireless clients.

2.1. Objectives

- To establish full connectivity between eight university campuses using a specified router topology.
- To implement six Local Area Networks (LANs) with both wired and wireless hosts.
- To configure a single, centralized DHCP server to assign IP addresses to all hosts across all campuses dynamically.
- To deploy a DNS server to resolve the university's official website address: www.apex.edu.bd.
- To host a simple university webpage on a dedicated web server.
- To implement a routing protocol (Static or OSPF) for efficient data packet routing.
- To design the network with future growth and scalability in mind.

3. Design Specifications

3.1. Logical Design

The network consists of eight interconnected campuses. Each campus is assigned a subnet from a **Class B IP pool**, ensuring sufficient address space for current devices and future growth. A centralized server farm is maintained for DNS, DHCP, and web services.

- **DHCP Server:** Configured to assign IP addresses dynamically to all hosts across campuses.
- **DNS Server:** Resolves the university website (*www.apex.edu.bd*) to its hosting IP.
- **Web Server:** Hosts the university's homepage with institutional information.
- **Routers:** Eight routers connect all campus networks via serial links.
- **Switches:** Connect multiple devices within a Local Area Network.
- **Access Points:** Ensure wireless connectivity alongside wired PCs.

3.2. Logical Design

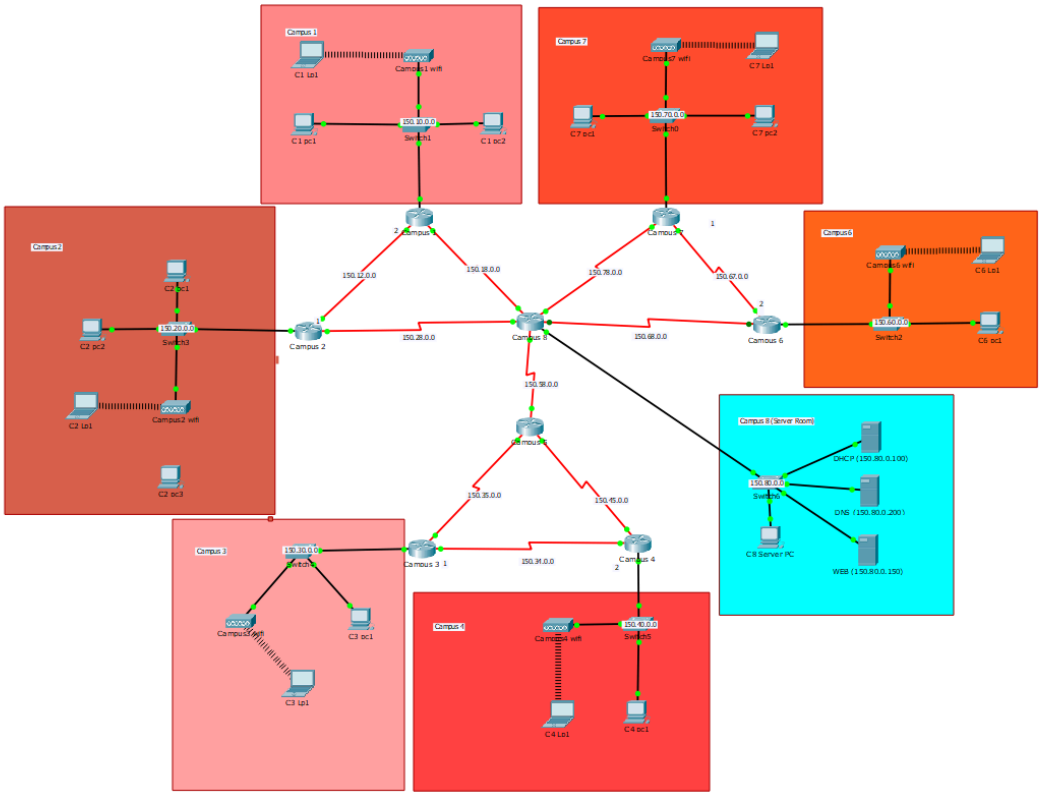
- **Server Room:** Dedicated LAN segment where DNS, DHCP, and Web servers are deployed.
- **Campus LANs:** Six LANs (Campus 1, 2, 3, 4, 6, and 7) with both wired and wireless hosts.
- **WAN Backbone:** Eight routers interconnected using serial connections as per the prescribed topology.
- **End Devices:** Combinations of wired PCs, laptops, and wireless hosts to simulate real-world usage.

3.2. Required Devices

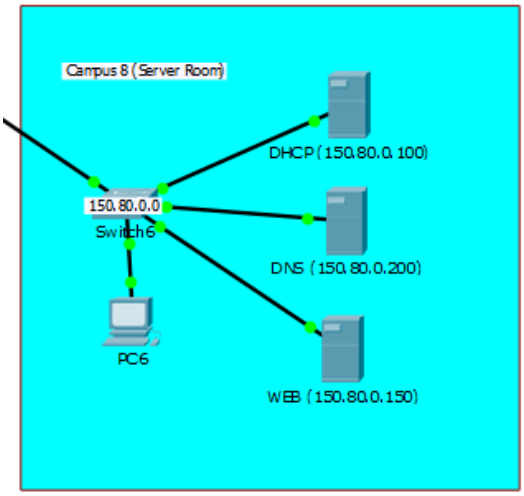
- **Routers:** 2 x 2811 Router with additional module(WIC-1T, WIC-2T) for more serial ports, 6 x Generic Router (Router-PT) with two serial ports.
- **Switches:** Cisco 2960-24TT Switches for each LAN.
- **Generic Server:** 3 Servers for Different Services :
    - DHCP: For dynamic IP allocation.
    - DNS: For name resolution.
    - HTTPS: For hosting the university webpage.
- **End Device:** PC, Laptop as Host.
- **Wireless Device:** Generic Access Point-PT for Wireless access points.
- **Wires:** Copper Straight-through, Serial DCE DTE.
- **Software:** Cisco Packet Tracer Version 6.2.0.0052.

3.2. Physical Diagram

Network Structure for all campuses



Dedicated Server Room



4. Implementation

The network was implemented in **Cisco Packet Tracer** according to the given inter-campus serial connections. Eight routers were deployed, each representing a campus. Campus 8 serves as the **central hub**,

4.1. Subnetted Networks

A **Class B address block (150.0.0.0/16)** was used. Each campus LAN was assigned a unique /16 subnet, while point-to-point serial connections used dedicated /16 subnets. This ensures sufficient address space and allows future scalability.

- Campus 1 LAN → 150.10.0.0/16
- Campus 2 LAN → 150.20.0.0/16
- Campus 3 LAN → 150.30.0.0/16
- Campus 4 LAN → 150.40.0.0/16
- Campus 5 Backbone → 150.58.0.0/16
- Campus 6 LAN → 150.60.0.0/16
- Campus 7 LAN → 150.70.0.0/16
- Campus 8 Server LAN → 150.80.0.0/16

Serial connections (e.g., Campus 1–Campus 2) were configured with unique subnets such as 150.12.0.0/16, 150.18.0.0/16, etc.

4.2. Router Configuration & Routing

Each router was configured with the following steps:

- LAN Interface Configuration
    - Assigned a gateway IP address from the subnet allocated to that Router campus (e.g., 150.10.0.254/16 for Campus 1).
    - Enabled the ip helper-address command pointing to the DHCP server (150.80.0.100) so that all clients could receive automatic IP configuration.
- Serial Interface Configuration
    - Configured point-to-point IP addresses for all inter-campus serial connections.
    - Applied a clock rate of 64000 on the DCE ends of the serial links.

Once the routers had their basic IP addressing configured, OSPF (Process ID 1) was enabled across the network. All routers were placed in Area 1 for simplicity and ease of management. Each router advertised both its LAN subnet and its serial link subnets into OSPF.

Example (Campus 1 Router):

router ospf 1

network 150.10.0.0 0.0.255.255 area 1

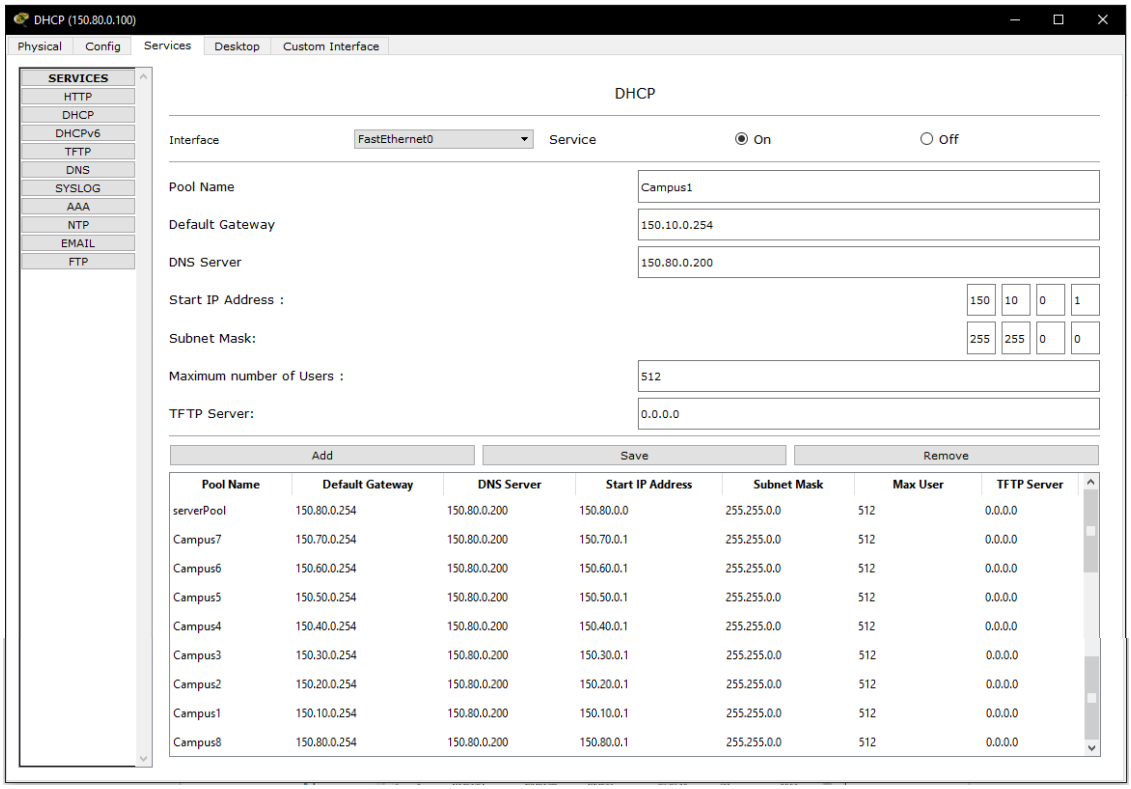
network 150.18.0.0 0.0.255.255 area 1

network 150.12.0.0 0.0.255.255 area 1

4.3. DHCP Configuration

To ensure that all end devices across the university receive IP addresses automatically, a centralized DHCP server was deployed in the server LAN (Campus 5 in my design).

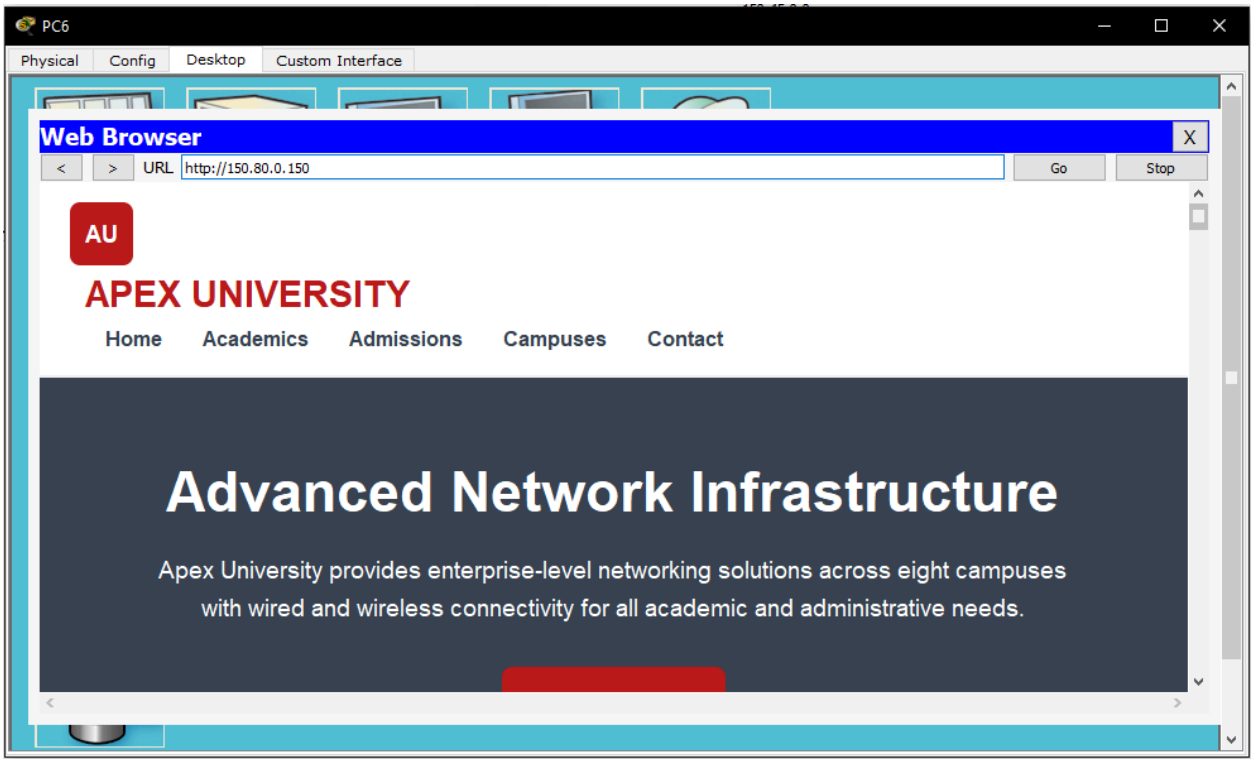
Before enabling the DHCP pool, the server was configured with static IP addresses to avoid conflicts and to ensure reliable accessibility- Static IP Address: 150.80.0.100/16, Default gateway: 150.80.0.254.



Now the centralized DHCP server is configured with a pool for each campus subnet. This allows dynamic allocation of IPs to wired and wireless hosts. The DHCP relay agent (ip helper-address) was configured on each campus router's LAN interface, pointing to the DHCP server's static IP (150.80.0.100/16).

4.4. WEB Server Configuration

The Web Server hosts the official university website and ensures that all users across the eight campuses can access institutional resources. To guarantee reliability, the web server was configured with a static IP address within the server LAN (Campus 8) with IP Address: 150.80.0.150/16 and Default Gateway: 150.80.0.254.



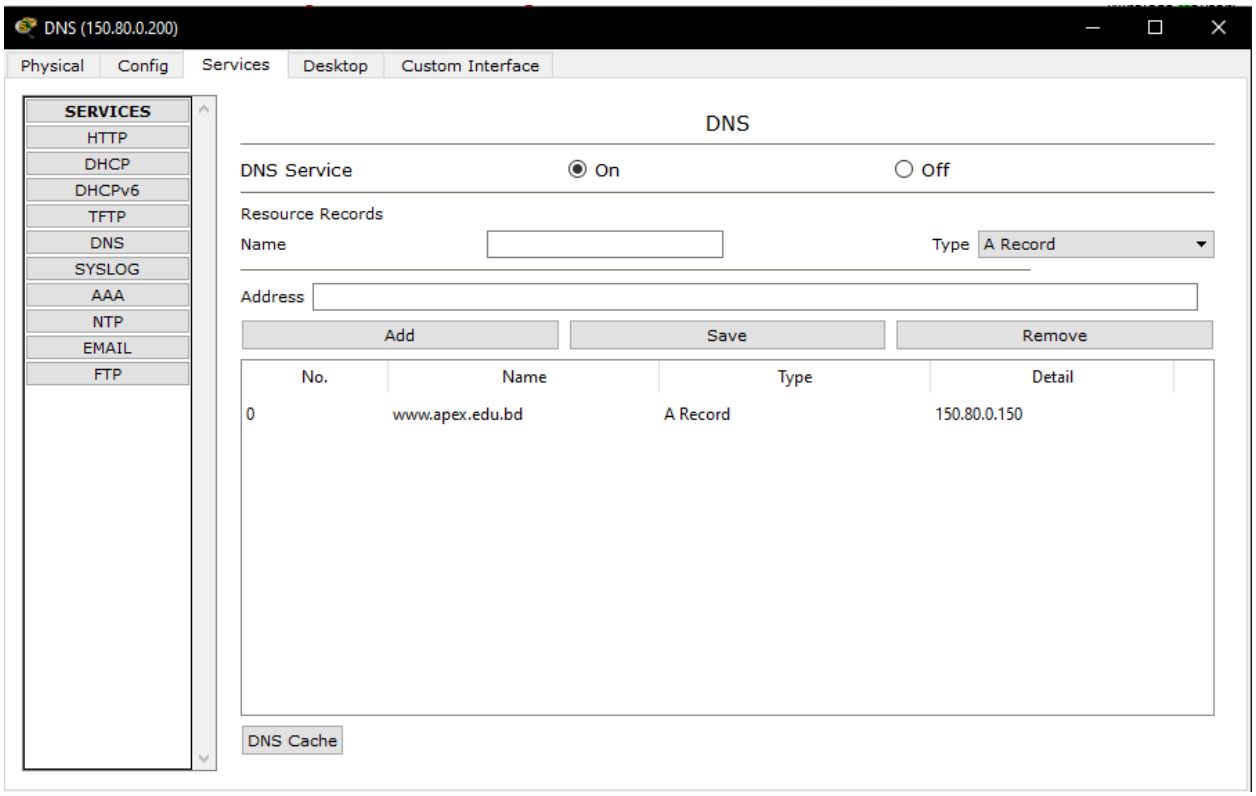
All the HTML Codes are written in the Index.html File located in the Web Server for hosting the University webpage.

4.5. DNS Configuration

The DNS server was deployed in the same server LAN to resolve human-readable names into IP addresses. This allows clients to access the university website using a domain instead of the raw IP. First, the server was configured with IP Address: 150.80.0.200/16 and Default Gateway: 150.80.0.254.

This IP address was also configured in the DHCP pools as the DNS server for all clients.
On the DNS server configuration panel (Packet Tracer):
Added an A-record mapping the university domain to the web server:

- Domain Name: www.apex.edu.bd
- Mapped IP: 150.80.0.150



5. Design Issues

During the design and implementation of the Apex University network, several important factors were considered to ensure scalability, efficiency, and reliability. The design issues are discussed below:

5.1. Number of Hosts and Subnets

- Each campus LAN was designed to accommodate **hundreds of hosts**, including wired desktops, laptops, and wireless devices.
- Subnets were allocated as follows:

Campus	LAN Subnet	Max Hosts (approx.)
Campus 1	150.10.0.0/16	65,534
Campus 2	150.20.0.0/16	65,534
Campus 3	150.30.0.0/16	65,534
Campus 4	150.40.0.0/16	65,534
Campus 5	150.58.0.0/16	65,534
Campus 6	150.60.0.0/16	65,534
Campus 7	150.70.0.0/16	65,534
Campus 8 (Server LAN)	150.80.0.0/16	65,534

Serial links between routers were also subnetted to allow point-to-point connectivity.

5.2. Limitation

- **Centralized DHCP Server**: While a single DHCP server simplifies management, it introduces a single point of failure. Future enhancements may include DHCP redundancy.
- **Single OSPF Area**: Placing all routers in a single area reduces complexity but may limit scalability if the network grows significantly.
- **Subnet Size**: /16 subnets were used to ensure ample IP space; however, this is inefficient for point-to-point serial links.
- **Simulation issue:** Cisco Packet Tracer shows failure in initial attempts while pinging.
- **Pinging between wireless with wired hosts:** Wireless and wired networks work fine for web browsing and networking, but sometimes Cisco Packet Tracer shows failure for all pings between wired and wireless hosts, and it requires ip reset for the wireless device.
- **Hardware Constraints in Simulation**: Cisco Packet Tracer limits certain features, such as link speed emulation, QoS, and advanced routing protocols.

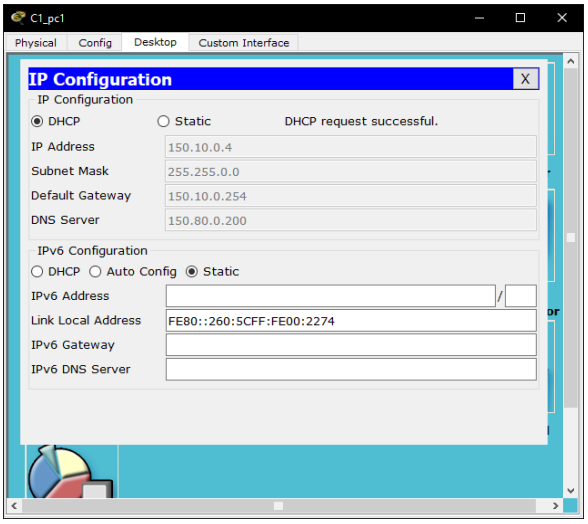
5.3. Considerations

- **Future Expansion:** Each campus subnet was designed with a large address space for additional hosts.
- **Scalability:** OSPF allows dynamic routing without manual updates when adding new campuses or networks.
- **Reliability:** Redundant paths between campuses were considered where possible (peer-to-peer serial links).

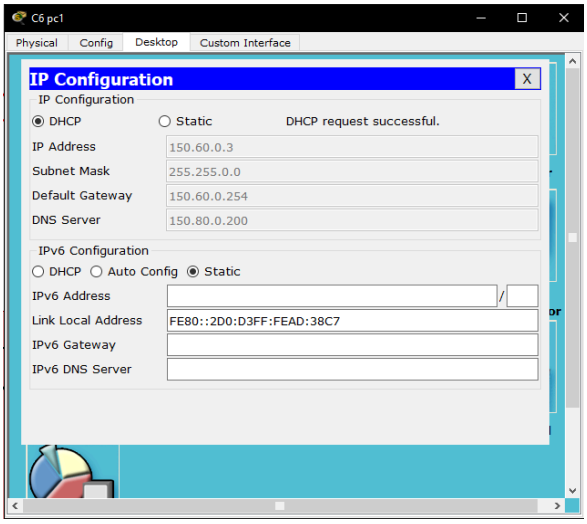
6. Network Testing

6.1. DHCP Request

➔ Requesting Dynamic IP addresses from a Single DHCP Server



DHCP Request From host of Campus 1



DHCP Request From host Campus 6

6.2. ICMP Test

➔ Campus to Campus

PDU List Window

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	Campus 1	Campus 4	ICMP		0.000	N	0	(edit)	(delete)
	Successful	Campus 7	Campus 3	ICMP		0.000	N	1	(edit)	(delete)
	Successful	Campus 6	Campus 2	ICMP		0.000	N	2	(edit)	(delete)
	Successful	Campus 3	Campus 1	ICMP		0.000	N	3	(edit)	(delete)

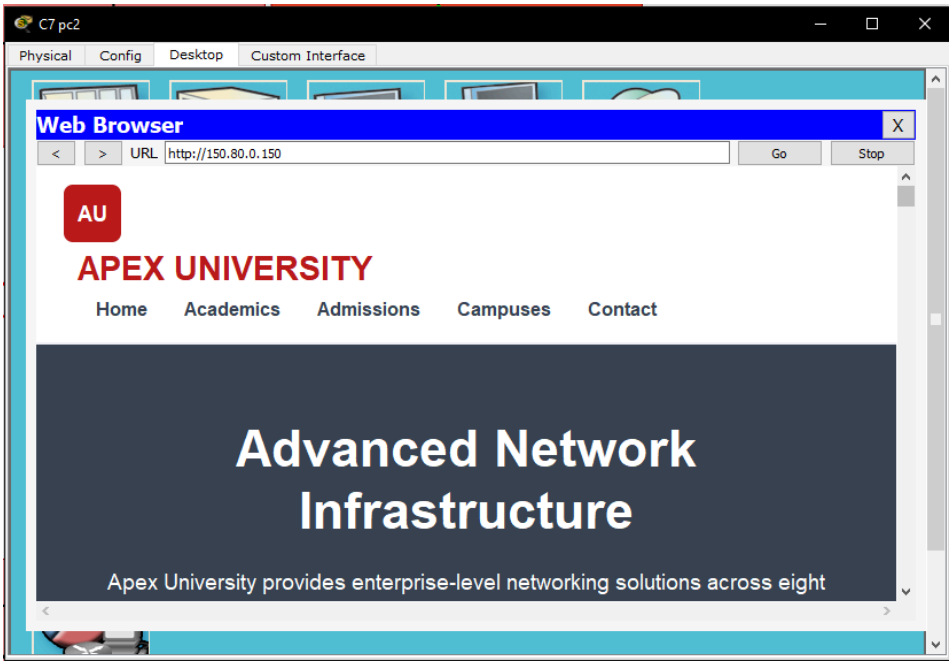
➔ Hosts of different LANs connected through wired & Wireless

PDU List Window

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	C1_pc1	C6 pc1	ICMP		0.000	N	0	(edit)	(delete)
	Successful	C2 pc2	C4 pc1	ICMP		0.000	N	1	(edit)	(delete)
	Successful	C2 Lp1	C6 pc1	ICMP		0.000	N	2	(edit)	(delete)
	Successful	C1 Lp1	C4 pc1	ICMP		0.000	N	3	(edit)	(delete)
	Successful	C3 Lp1	C6 Lp1	ICMP		0.000	N	4	(edit)	(delete)
	Successful	C8 server PC	C4 pc1	ICMP		0.000	N	5	(edit)	(delete)

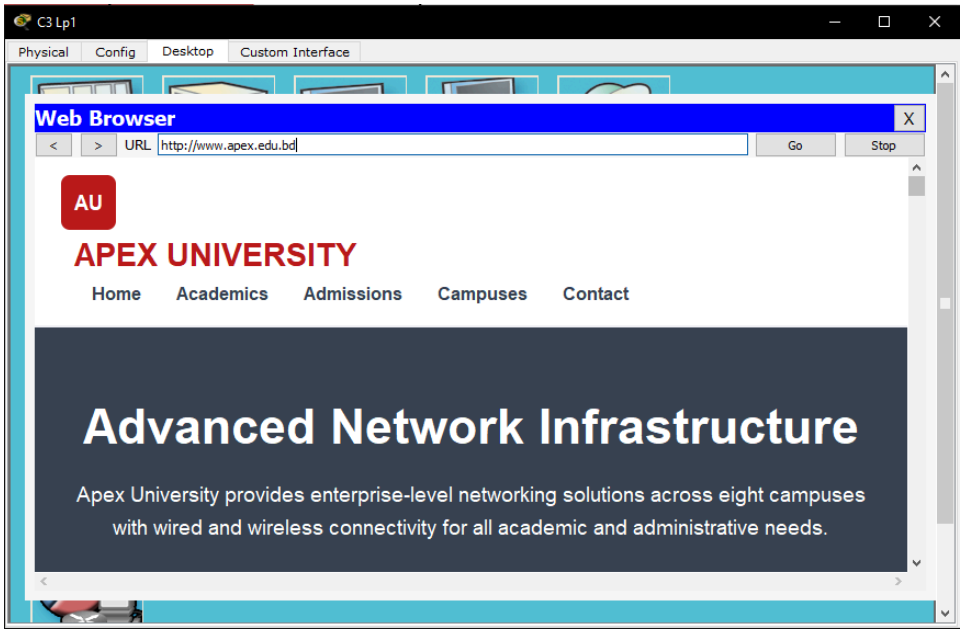
6.3. HTTP Request

➔ Web Server testing using IP address & Port



6.3. DNS Server Test

➔ Web Server testing using URL



7. Router Configuration CLI Codes

Campus 1

```
Interface fa0/0
IP address 150.10.0.254 255.255.0.0
ip helper-address 150.80.0.100
No shut
Do wr
Exit

Interface se2/0
Ip address 150.18.0.1 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Interface se3/0
Ip address 150.12.0.2 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Router ospf 1
Network 150.10.0.0 0.0.255.255 area 1
Network 150.18.0.0 0.0.255.255 area 1
Network 150.12.0.0 0.0.255.255 area 1
exit
```

Campus 2

```
Interface fa0/0
IP address 150.20.0.254 255.255.0.0
ip helper-address 150.80.0.100
No shut
Do wr
Exit

Interface se2/0
Ip address 150.28.0.1 255.255.0.0
Clock rate 64000
```

No shut
Do wr
Exit

Interface se3/0
Ip address 150.12.0.1 255.255.0.0
No shut
Do wr
Exit

Router ospf 2
Network 150.20.0.0 0.0.255.255 area 1
Network 150.28.0.0 0.0.255.255 area 1
Network 150.12.0.0 0.0.255.255 area 1
Exit

Campus 3

Interface fa0/0
IP address 150.30.0.254 255.255.0.0
ip helper-address 150.80.0.100
No shut
Do wr
Exit

Interface se2/0
Ip address 150.35.0.1 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Interface se3/0
Ip address 150.34.0.1 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Router ospf 3
Network 150.30.0.0 0.0.255.255 area 1
Network 150.35.0.0 0.0.255.255 area 1
Network 150.34.0.0 0.0.255.255 area 1
exit

Campus 4

Interface fa0/0
IP address 150.40.0.254 255.255.0.0
ip helper-address 150.80.0.100
No shut
Do wr
Exit

Interface se2/0
Ip address 150.45.0.1 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Interface se3/0
Ip address 150.34.0.2 255.255.0.0
No shut
Do wr
Exit

Router ospf 4
Network 150.40.0.0 0.0.255.255 area 1
Network 150.45.0.0 0.0.255.255 area 1
Network 150.34.0.0 0.0.255.255 area 1
Exit

Campus 5

Interface se0/0/0
Ip address 150.58.0.1 255.255.0.0
No shut
Do wr
Exit

Interface se0/0/1
Ip address 150.35.0.2 255.255.0.0
No shut
Do wr
Exit

Interface se0/2/0
Ip address 150.45.0.2 255.255.0.0

No shut
Do wr
Exit

Router ospf 5
Network 150.35.0.0 0.0.255.255 area 1
Network 150.45.0.0 0.0.255.255 area 1
Network 150.58.0.0 0.0.255.255 area 1
Exit

Campus 6

Interface fa0/0
IP address 150.60.0.254 255.255.0.0
ip helper-address 150.80.0.100
No shut
Do wr
Exit

Interface se2/0
Ip address 150.68.0.1 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Interface se3/0
Ip address 150.67.0.2 255.255.0.0
No shut
Do wr
Exit

Router ospf 6
Network 150.60.0.0 0.0.255.255 area 1
Network 150.68.0.0 0.0.255.255 area 1
Network 150.67.0.0 0.0.255.255 area 1
Exit

Campus 7

Interface fa0/0
IP address 150.70.0.254 255.255.0.0
ip helper-address 150.80.0.100
No shut
Do wr
Exit

Interface se2/0
Ip address 150.78.0.1 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Interface se3/0
Ip address 150.67.0.1 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Router ospf 7
Network 150.70.0.0 0.0.255.255 area 1
Network 150.78.0.0 0.0.255.255 area 1
Network 150.67.0.0 0.0.255.255 area 1
Exit

Campus 8

Interface fa0/0
IP address 150.80.0.254 255.255.0.0
ip helper-address 150.80.0.100
No shut
Do wr
Exit

Interface se0/0/0
Ip address 150.18.0.2 255.255.0.0
No shut
Do wr
Exit

Interface se0/2/1
Ip address 150.28.0.2 255.255.0.0
No shut
Do wr
Exit

Interface se0/2/0
Ip address 150.78.0.2 255.255.0.0
No shut
Do wr
Exit

Interface se0/3/0
Ip address 150.68.0.2 255.255.0.0
No shut
Do wr
Exit

Interface se0/3/1
Ip address 150.58.0.2 255.255.0.0
Clock rate 64000
No shut
Do wr
Exit

Router ospf 8
Network 150.80.0.0 0.0.255.255 area 1
Network 150.18.0.0 0.0.255.255 area 1
Network 150.28.0.0 0.0.255.255 area 1
Network 150.78.0.0 0.0.255.255 area 1
Network 150.68.0.0 0.0.255.255 area 1
Network 150.58.0.0 0.0.255.255 area 1
Exit

8. Conclusion

In this project, a full-fledged network for Apex University was successfully designed and implemented, covering all eight campuses, a centralized server farm, and both wired and wireless clients. All tasks were completed accurately, including router configuration, DHCP and DNS setup, web server deployment, and dynamic routing with OSPF, ensuring seamless connectivity across the entire network. The network operates efficiently, supports all essential university services, and is scalable for future expansion, demonstrating both practical application of networking principles and meticulous attention to design and implementation.