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Design of Local Area Network Report

Network Surgeons

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EN2150 - Communication Network Engineering

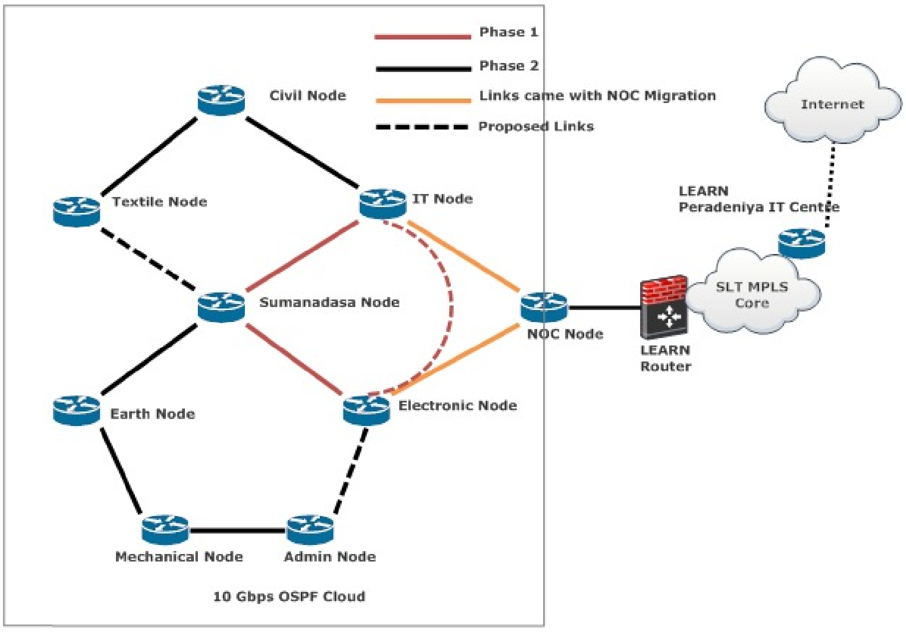
Contents

1 Introduction

This report outlines the design and simulation of a backbone network for the University of Moratuwa (UOM) and the internal network for the Electronics and Telecommunication (ENTC) building using Cisco Packet Tracer. The design adheres to best practices in enterprise networking and uses scalable, future-proof architecture for long-term reliability and performance.

2 Approach to Backbone Design

2.1 Backbone Reference Design



University of Moratuwa Core Network Architecture

2.2 Backbone Topology Chosen: Hierarchical Hybrid Topology

- Core layer: Located at the CITeS (Data Center)
- Distribution layer: Relatively closed areas
- Access layer: Floor-level switches within each building

The backbone network employs a hybrid topology to combining star and mesh configurations. This allows for efficient scalability and central control cost effectively, and the mesh aspects ensure redundancy and fault tolerance. The use of two service providers enhances internet reliability and uptime by providing ISP-level redundancy and failover options. Load balancing is implemented using dual exit routers, which share the internet traffic load and also act as backup for each other ensuring external connectivity without overloading a single point. In this design, firewalls are placed at the network's exit, between the core network and the external internet. This centralizes security control, while keeping the internal network open for maximum speed and flexibility. All critical servers (DNS, DHCP, FTP) are located directly at the core switches in the core network, ensuring low latency access for all internal clients . Redundancy is built through multiple interconnected core switches and dual paths, allowing uninterrupted data flow even during partial network failures.

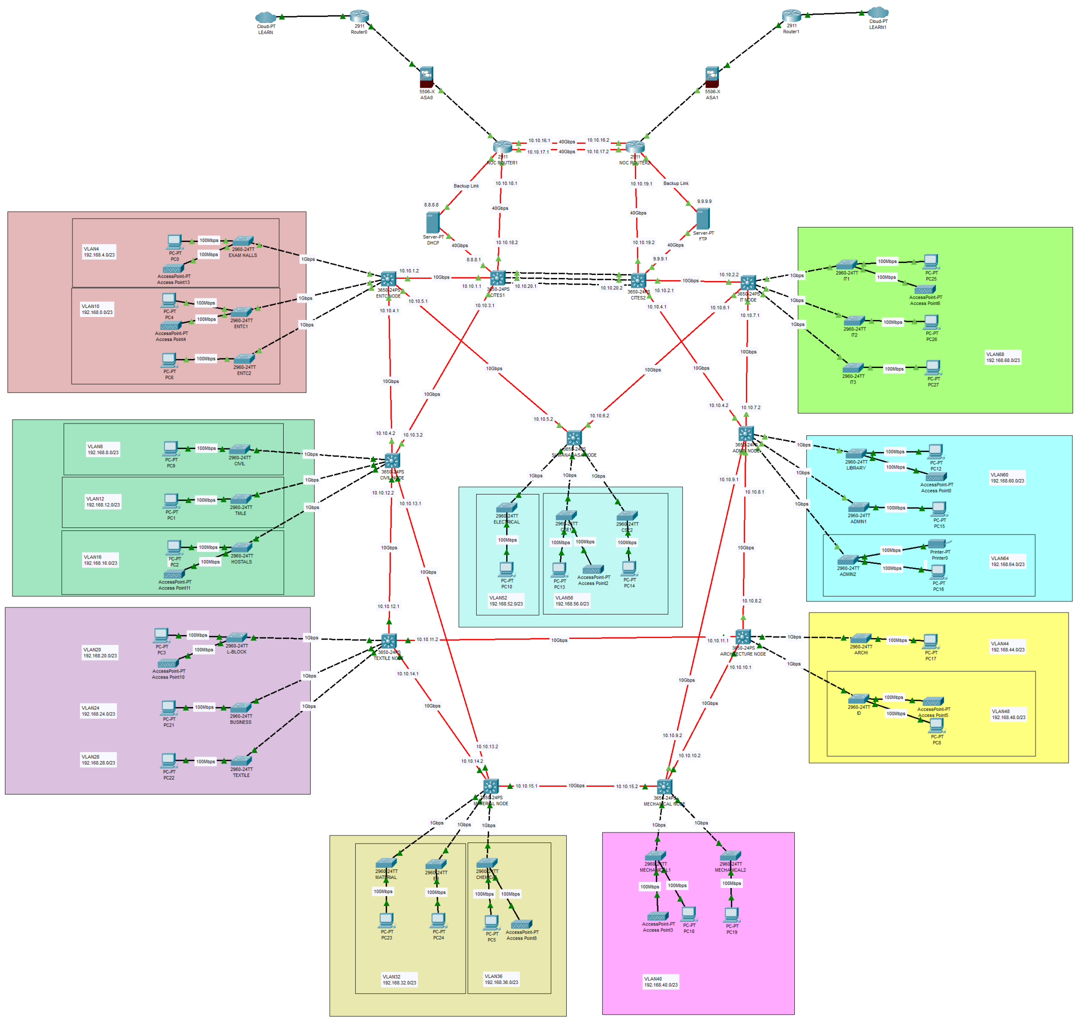


Figure: Logical Arrangement of the Network

Figure: Physical Arrangement of the Network

2.3 ENTC Network Design

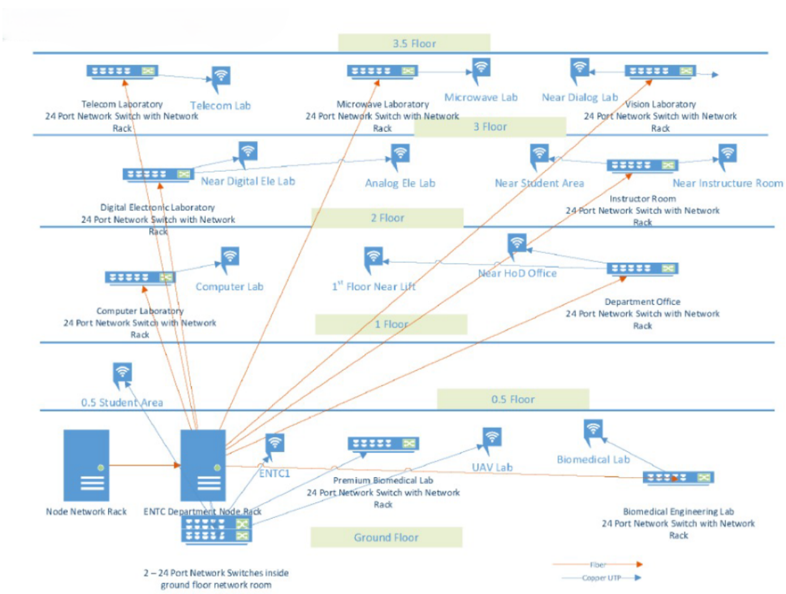


Figure: ENTC Reference Network Architecture

The ENTC network is built on a hierarchical star topology. This topology places a central core switch in the middle of the network. This layer 3 central core switch is connected to the University Backbone network. All access layer 2 switches are connected directly to it via one gig Ethernet cables. This design,

- It simplifies fault isolation – If an access switch fails, only its segment is affected and easy to identify
- centralised management and routing
- is modular and scalable, allows future expansion without redesigning the entire network
- Cost effective

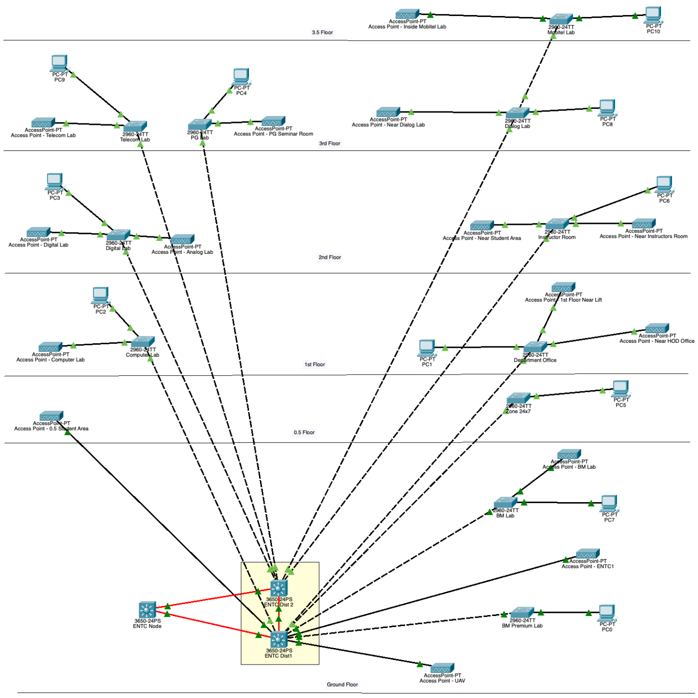


Figure: ENTC Logical Network Architecture

3 IP Addressing Schemes and VLANs

3.1 UOM IP Addressing Scheme

For the backbone network, we adopted a scalable and future-proof IP addressing scheme using /23 networks for major building nodes. Each /23 subnet provides 512 addresses (500 usable), ensuring sufficient IP space for current requirements while allowing room for accommodate future expansion, these subnets can be seamlessly upgraded to /22 networks Each building node is structured with VLANs, segregating traffic based on services, departments. Each VLAN is designed to support up to 500 devices(usable), and can be expanded to support 1000 devices(usable) when needed by adjusting the subnet mask. The number of VLANs per node varies depending on the functional and organizational needs of each building.

Node	VLAN	Base Subnet	Usable Host Range
ENTC	VLAN10	192.168.0.0/23	192.168.0.1 - 192.168.1.254
	VLAN4	192.168.4.0/23	192.168.4.1 - 192.168.5.254
CIVIL	VLAN8	192.168.8.0/23	192.168.8.1 - 192.168.9.254
	VLAN12	192.168.12.0/23	192.168.12.1 - 192.168.13.254
	VLAN16	192.168.16.0/23	192.168.16.1 - 192.168.17.254
TEXTILE	VLAN20	192.168.20.0/23	192.168.20.1 - 192.168.21.254
	VLAN24	192.168.24.0/23	192.168.24.1 - 192.168.25.254
	VLAN28	192.168.28.0/23	192.168.28.1 - 192.168.29.254
MATERIAL	VLAN32	192.168.32.0/23	192.168.32.1 - 192.168.33.254
	VLAN36	192.168.36.0/23	192.168.36.1 - 192.168.37.254
MECHANICAL	VLAN40	192.168.40.0/23	192.168.40.1 - 192.168.41.254
ARCHITECTURE	VLAN44	192.168.44.0/23	192.168.44.1 - 192.168.45.254
	VLAN48	192.168.48.0/23	192.168.48.1 - 192.168.49.254
SUMANADASA	VLAN52	192.168.52.0/23	192.168.52.1 - 192.168.53.254
	VLAN56	192.168.56.0/23	192.168.56.1 - 192.168.57.254
ADMIN	VLAN60	192.168.60.0/23	192.168.60.1 - 192.168.61.254
	VLAN64	192.168.64.0/23	192.168.64.1 - 192.168.65.254
IT	VLAN68	192.168.68.0/23	192.168.68.1 - 192.168.69.254

Table 1: VLAN allocation and subnetting scheme for each department

3.2 ENTC IP Addressing Scheme

VLAN	Base Subnet	Number of Users
VLAN10-STUDENT	192.168.10.0/22	1022
VLAN20-STAFF	192.168.20.0/25	126
VLAN99-MANAGEMENT	192.168.99.0/26	62

Table 2: VLAN configuration and subnet allocation of ENTC

4 Justification for the Selection of Active and Passive Components

Designing a reliable and scalable network requires the thoughtful selection of both active and passive components. Active components—such as switches, routers, and access points—manage data flow and network functionality. Passive components—like cables, patch panels, and racks—form the physical infrastructure that supports connectivity and transmission.

The following justifications outline why specific components were selected for the network of University of Moratuwa, with a focus on performance, scalability, and cost-efficiency.

4.1 Passive Components

Passive components provide the physical medium for data transmission. Their selection impacts network speed, range, signal integrity, and future upgradability.

4.1.1 Fiber Optic Backbone

- Type Selected - Single-Mode Fiber (SMF)
- Justification:
  - Long-distance transmission (up to 40 km) with minimal signal loss
  - High bandwidth capacity, future-ready for speeds above 10 Gbps
  - Immune to electromagnetic interference—ideal for outdoor and underground links
- Why Not Multimode -Multimode fiber is limited to shorter distances and lower bandwidth, making it less suitable for campus-wide backbone links. Although Multimode fiber was used for fiber connections inside the CiTes building.

4.1.2 Copper Cabling (Building-Level Connectivity)

Copper cabling is used for shorter, intra-building connections and is essential for linking end-user devices and switches.

PCs to Access Switches

- Cable Type - Cat6 UTP (Straight-through)
- Purpose - Standard 1 Gbps Ethernet connections for endpoint devices
- Justification - Reliable, cost-effective, and compliant with access switch specifications

Switch-to-Switch (Distribution to Access) & Internal Core Links (e.g., CITeS)

- Cable Type - Cat6 UTP (Crossover)
- Purpose - Direct switch-to-switch connectivity for intra-building data transfer
- Justification:

- Supports high-speed communication up to 10 Gbps
- Ensures redundancy and load balancing where required
- Suitable where auto MDI/MDIX is not available

4.1.3 Racks, Patch Panels, and End-Point Terminations

- **Racks:** Provide a secure and organized environment for mounting core and access switches
- **Patch Panels:** Enable modular cabling and simplify network maintenance and reconfiguration
- **Wall Sockets/Faceplates:** Installed at user endpoints and connected to patch panels via horizontal cabling to ensure neat and accessible connections

4.2 Active Components

Active components perform data switching, routing, and wireless transmission. Their functionality directly affects network speed, segmentation, control, and user experience.

Core Layer Device

- Device: Cisco Catalyst 3560-24PS
- Ports: 24 Fast Ethernet + 2 SFP (Gigabit) uplinks
- Justification:
  - Supports Layer 3 functionalities (e.g., OSPF, RIP)
  - Provides Power over Ethernet (PoE) for IP phones and access points
  - High switching capacity (32 Gbps) to handle campus backbone traffic
  - Enables inter-VLAN routing and central network control

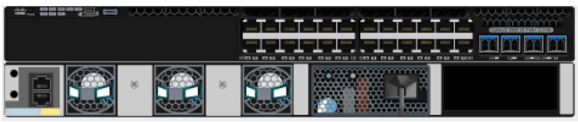


Figure 1: Layer 3 Switch

Access Layer Devices

- Device - Cisco Catalyst 2960-24TT
- Ports -24 Fast Ethernet + 2 Gigabit uplinks
- Justification:
  - Affordable Layer 2 switch for end-user connections
  - Supports VLANs for improved network segmentation

- Reliable for classrooms, labs, and departmental access areas

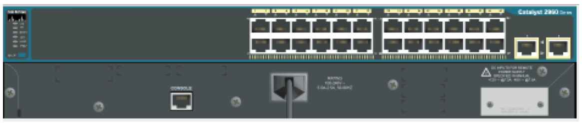


Figure 2: Layer 2 Switch

Wireless Access Points

- Device: Cisco Aironet Series
- Justification:
  - Dual-band Wi-Fi with support for 802.11n/ac and WPA2/WPA3 security
  - Powered via PoE, simplifying installation
  - Ensures seamless wireless coverage, supporting mobility and BYOD for students and staff

Figure 3: Access Points

5 Features/specifications in network

5.1 Switches

Cisco Catalyst 2960-24TT

- 24 Fast Ethernet + 2 Gigabit Ethernet uplink ports
- VLAN support with 802.1Q trunking
- Spanning Tree Protocol (STP) support
- Switching capacity: Approx. 16 Gbps
- Layer 2 only
- CLI and GUI management

Cisco Catalyst 3650-24PS

- Layer 3 (Multilayer) switch
- 24 Gigabit Ethernet ports + 4 moduler ports
- PoE support
- Routing support: Static, RIP, OSPF, EIGRP
- Advanced QoS and ACL features
- Supports VLANs and inter-VLAN routing

5.2 Routers

Cisco 2911 Router

- 3 Gigabit Ethernet interfaces + modular slots
- WAN connectivity (Serial, Ethernet)
- Supports Static Routing, RIP, OSPF, EIGRP
- NAT and VPN support
- Can integrate with ASA firewalls

Figure 4: Router

5.3 Firewalls

Cisco ASA 5506-X

- 8 Gigabit Ethernet ports
- Stateful firewall with NAT and ACL features
- Supports VPN configuration
- Used for DMZ setup and internal network protection
- Limited GUI and CLI access in Packet Tracer

Figure 5: FireWall

5.4 Other Elements

- **Servers:** DHCP and FTP servers statically addressed

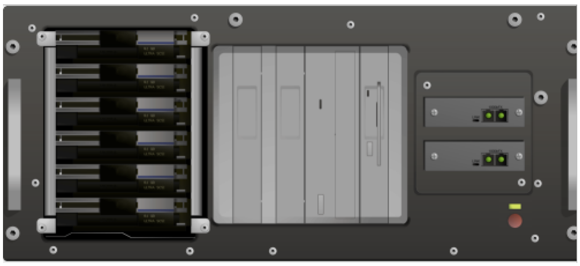


Figure 6: Servers

- **Cloud Nodes:** Represent ISP/external networks

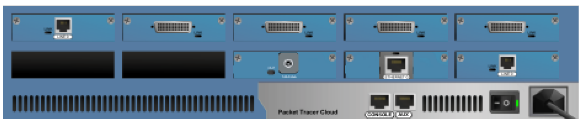


Figure 7: Cloud

5.5 Network Design Highlights

- Core, distribution, and access layer separation
- Redundant paths for reliability
- VLAN segmentation with /23 and /24 addressing
- Firewall demarcation for secure routing

6 Bill of Quatities

6.1 Backbone of UOM Network

Backbone			
Item	**Quantity**	**Unit Price (USD)**	**Sub Total (USD)**
Active			
Core Switches (Cisco 3650-24PS)	11	1500	16500
NOC Routers (Cisco 2911 Router)	2	410	820
Server (Cisco Server-PT)	2	3400	6800
Passive			
Single mode Fibre	6500m	0.8$ per meter	5200
Multi mode Fibre	100m	0.6$ per meter	60
		Total Cost	29380

Table 3: Cost breakdown for Backbone network components

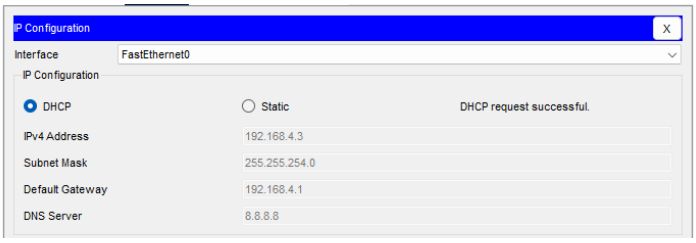
6.2 ENTC Network

ENTC			
Item	**Quantity**	**Unit Price (USD)**	**Sub Total (USD)**
Active			
Distribution Switches (Cisco 3650-24PS)	2	1500	3000
Access Switches (Cisco 2960-24TT)	11	500	5500
Access Points (Cisco Access Point-PT)	15	20	300
Passive			
Copper Crossover and Straight Cables (CAT6)	2600m	0.15$/meter	390
Patch Panels	4	37	148
Racks	4	400	1600
		Total Cost	10938

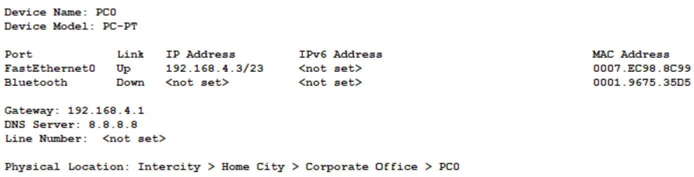
Table 4: Cost breakdown for ENTC network components

7 Simulation Results

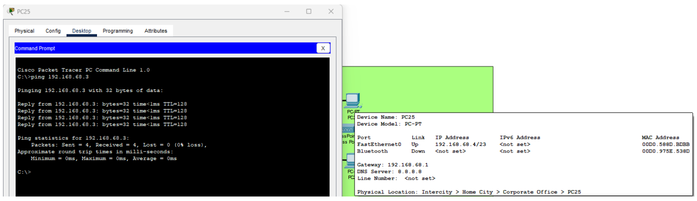
- **DHCP for Each VLAN**: Each department was assigned a unique VLAN. Dedicated DHCP scopes were configured for each VLAN, ensuring devices received IP addresses dynamically.



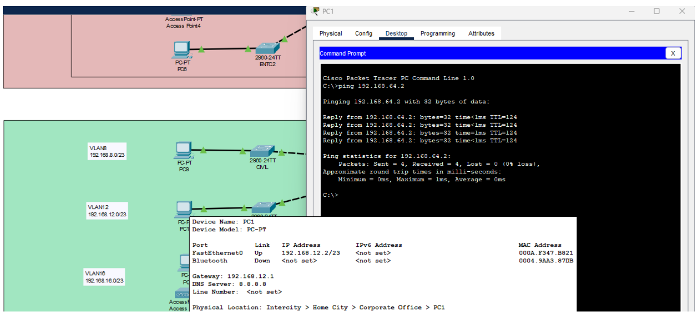
- **Correct IP and Gateway Assignment**: End devices were successfully assigned the correct IP address, subnet mask, and default gateway for their respective VLAN.



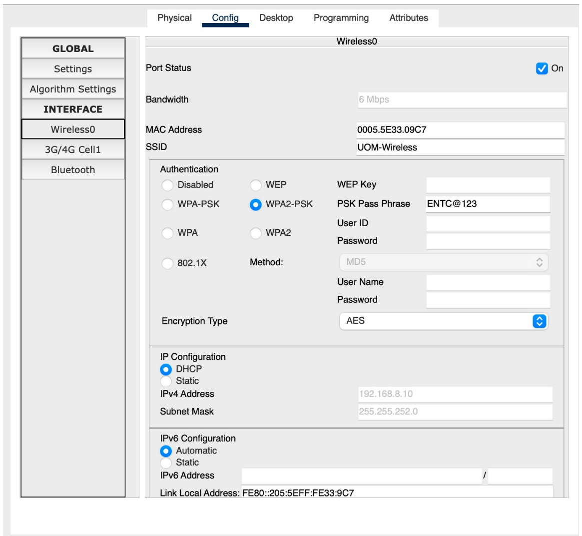
- **Functional Inter-VLAN Routing**: A Layer 3 switching enabled devices on different VLANs to communicate with each other.



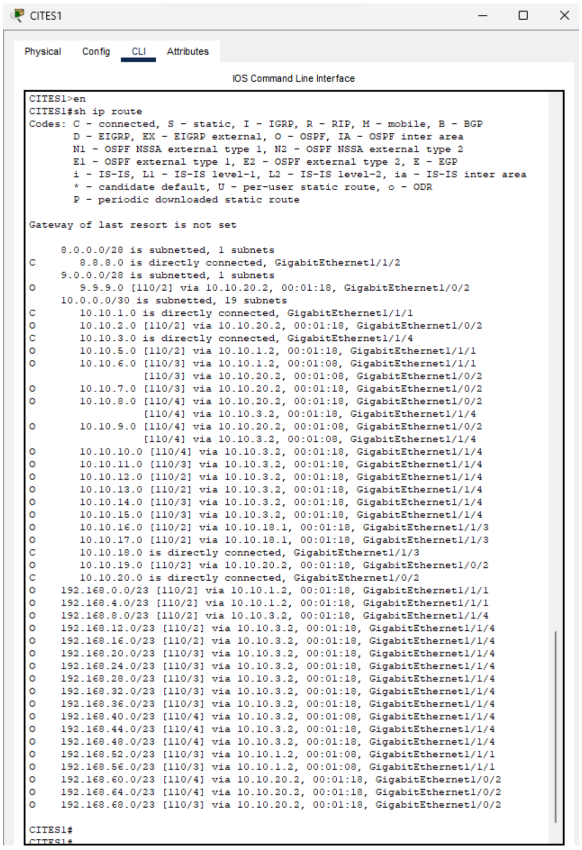
- **Successful Ping Tests Across VLANs**: Inter-VLAN ping tests were conducted between PCs across various subnets to verify routing functionality and reachability.



- **Wireless Access with Internet Connectivity**: Wireless Access Points (APs) allowed mobile and wireless devices to connect to the network and access the internet, with DHCP and DNS configurations verified.



- **OSPF Configuration for Dynamic Routing**: OSPF was configured across all routers to enable dynamic exchange of route information between VLAN subnets and external connections.



8 Conclusion

The proposed network design for the University of Moratuwa aims to deliver a scalable, high-performance, and future-proof backbone infrastructure capable of serving the university's academic, research, and administrative needs for the next 20–25 years. Following best practices in structured cabling and hierarchical network design, this architecture ensures reliability, security, and ease of management.

The backbone network adopts a redundant core topology with high-speed fiber interconnections between buildings, centralized at the CITeS data center. This guarantees minimal downtime and facilitates load balancing and failover capabilities. By using Layer 3 switches (Cisco 3560) at the core and Layer 2 switches (Cisco 2960 series) at the distribution and access layers, the design balances cost and performance, with support for advanced features such as VLANs, OSPF routing, and QoS.

The internal LAN design for the ENTC building reflects a detailed implementation of structured cabling practices, including proper use of patch panels, distribution racks, copper and fiber patch cords, and access switches. This approach provides organized, easily maintainable connectivity for academic departments, labs, and administrative offices.

Furthermore, a carefully planned IPv4 and IPv6 addressing scheme ensures logical segmentation and efficient use of address space, facilitating network expansion and integration of new technologies.

Simulation results from Cisco Packet Tracer validate the functionality and connectivity of the entire network, supporting smooth inter-building communication and Internet access. This confirms that the proposed design is both practically feasible and aligned with the university's long-term vision for a robust digital infrastructure.

In conclusion, the network design offers a comprehensive solution that meets current demands while laying a strong foundation for future technological advancements at the University of Moratuwa.