Department of Electronic and Telecommunication Engineering

University of Moratuwa

EN2150 – Communication Network Engineering

Design of Local Area Network – Group project

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Introduction

A backbone network design refers to the high-speed central infrastructure that connects multiple smaller networks or network segments within an organization or across multiple locations. It serves as the primary pathway for data transmission and facilitates communication between different parts of the network. Our goal is to design a LAN for the University of Moratuwa and the Department of Electronics and Telecommunication Engineering.

The Approach to the Backbone Design of University of Moratuwa

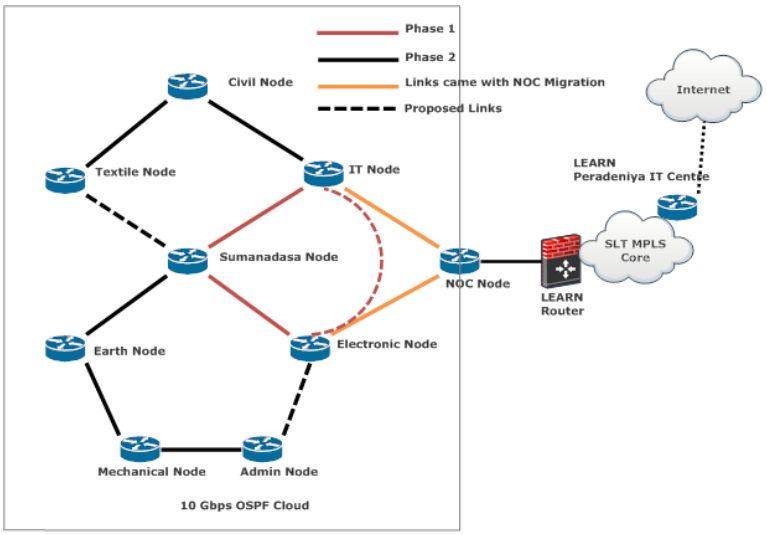
Features of the existing backbone network of University of Moratuwa

The network architecture of universities is set up in a ring topology. The backbone of the entire network is made up of nine (9) nodes. Layer 3 switches that are executing the OSPF protocol make up each and every node. A 1 Gbps multi-mode fiber cable connection serves as a backup across the network for disaster recovery, while a 10Gbps single-mode fiber channel is utilized for network traffic.

In the initial stage of setting up the university network infrastructure, four nodes were linked. They linked the SUM and IT nodes, the ENTC and SUM nodes, and the IT node. More nodes were linked during the second phase. IT to Civil to TEX and SUM to ERE to MEC to Admin

The Network Operating Center (NOC) was moved to a new site in September 2012. We had to cut the fiber connection between IT and ETC as a result of it. They linked the NOC nodes for IT and ENTC together. ENTC to Admin and SUM to TEX will now be connected via two new linkages that the university has previously suggested.

There is Lanka Education and Research Network and subscribed 240 Mbps internet bandwidth and 500Mbps local bandwidth through LEARN.



University of Moratuwa Core Network Architecture

Features of the local area network of the department building of Department of Electronic and Telecommunication Engineering

LAN of ENTC is a flat network and there is no VLAN has been divided inside the network. Through ENTC node, a layer 3 switch, the LAN of the ENTC department building is connected to the University of Moratuwa's backbone network.The highest data rate that an ENTC node switch can support is 10 Gigabits per second.The core switch of the ENTC LAN, which is once more a layer 3 switch, is connected to the ENTC node switch by a 10 Gigabits per second fiber connection.The following 8 24-Port Network Switches with a 2 layer topology have been linked to the ENTC core switch using 8 fiber cables at a speed of 1 Gigabit per second.

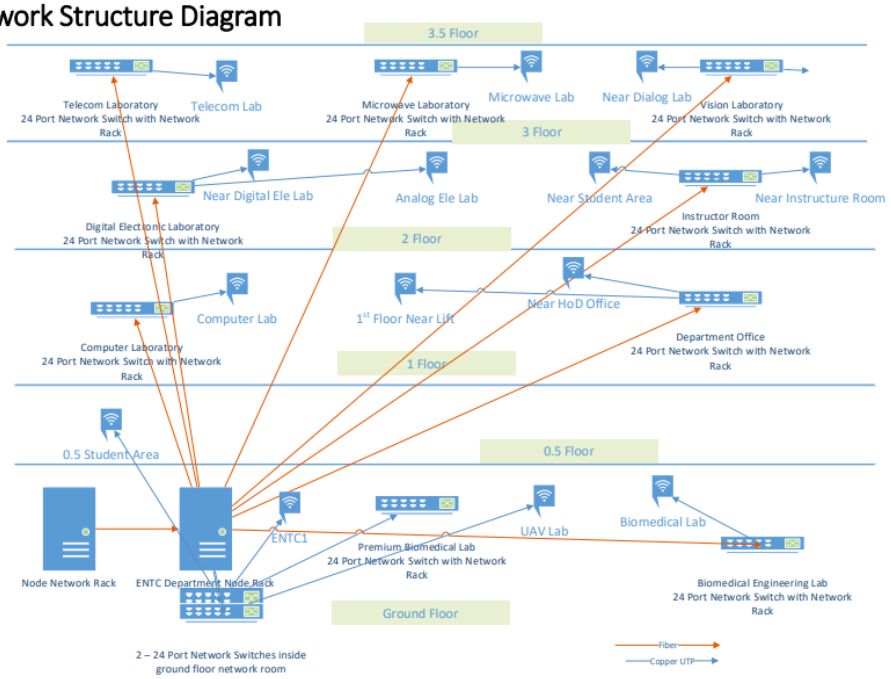
1) Biomedical Engineering Laboratory.
2) Computer Laboratory.
3) Department Office
4) Digital Electronic Laboratory.
5) Instructors' Room.
6) Telecommunication Laboratory.
7) Microwave Laboratory.
8) Vision Laboratory.

Copper UTP cables have been used to connect the following 24-Port network switches to the ENTC Core switch

1) Switch inside the Premium Biomedical Engineering laboratory
2) 2 switches inside the Network Room, Ground Floor.

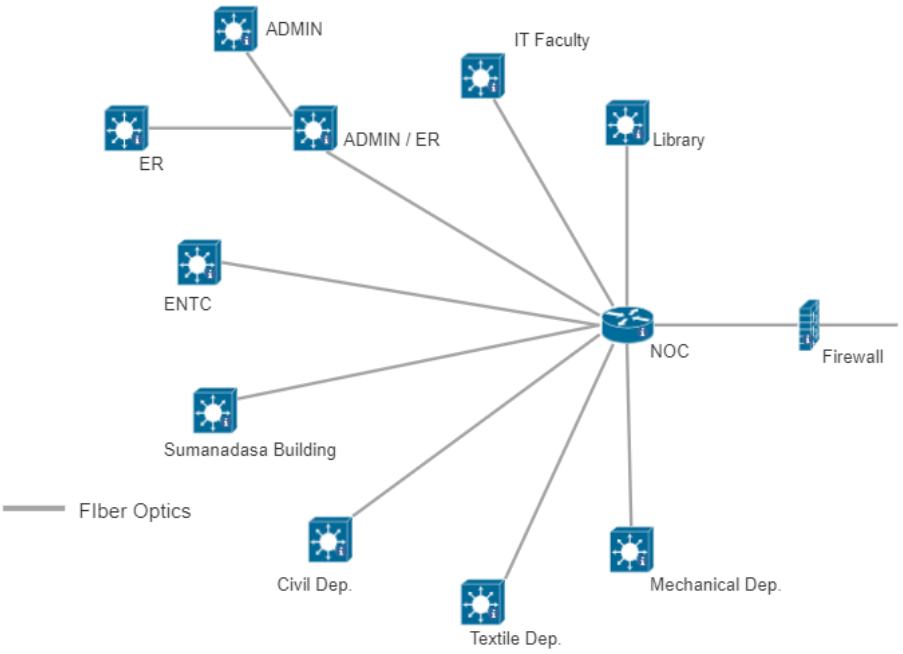
Furthermore,there are 14 wireless access points inside the building to access the LAN.

Overall Network Structure Diagram



Network diagram With all the Building Nodes and Bandwidth in each Link

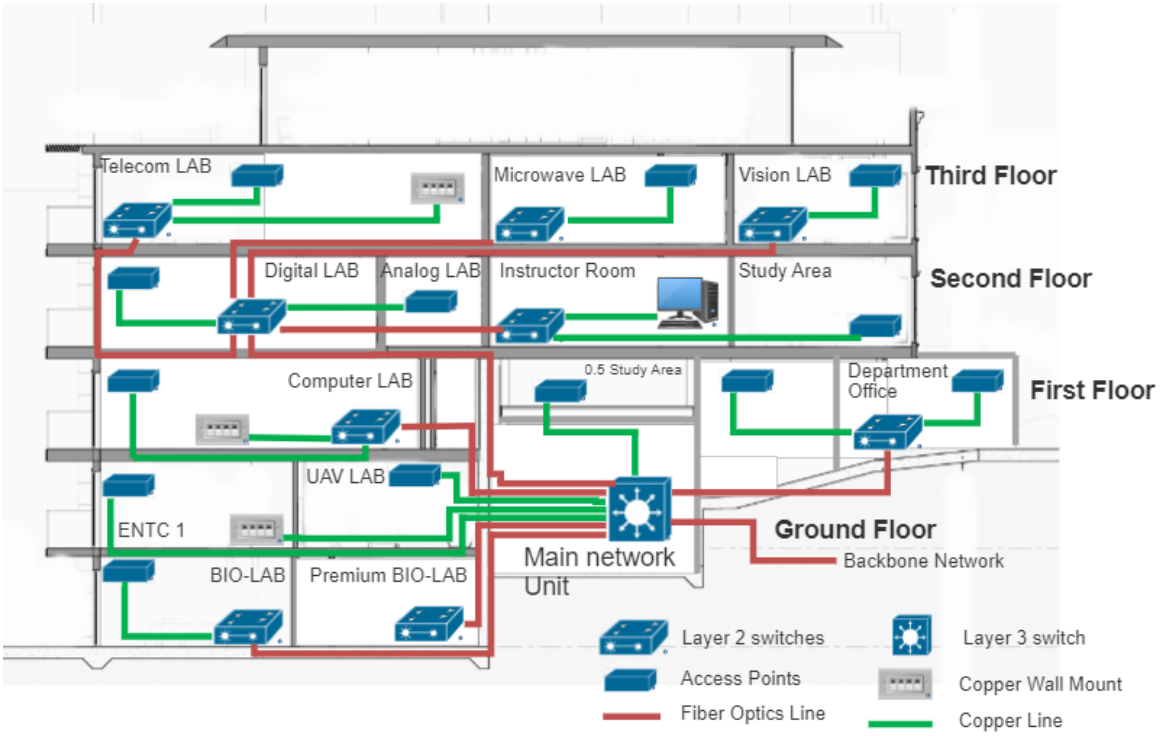
This is the proposed backbone network for the University of Moratuwa.

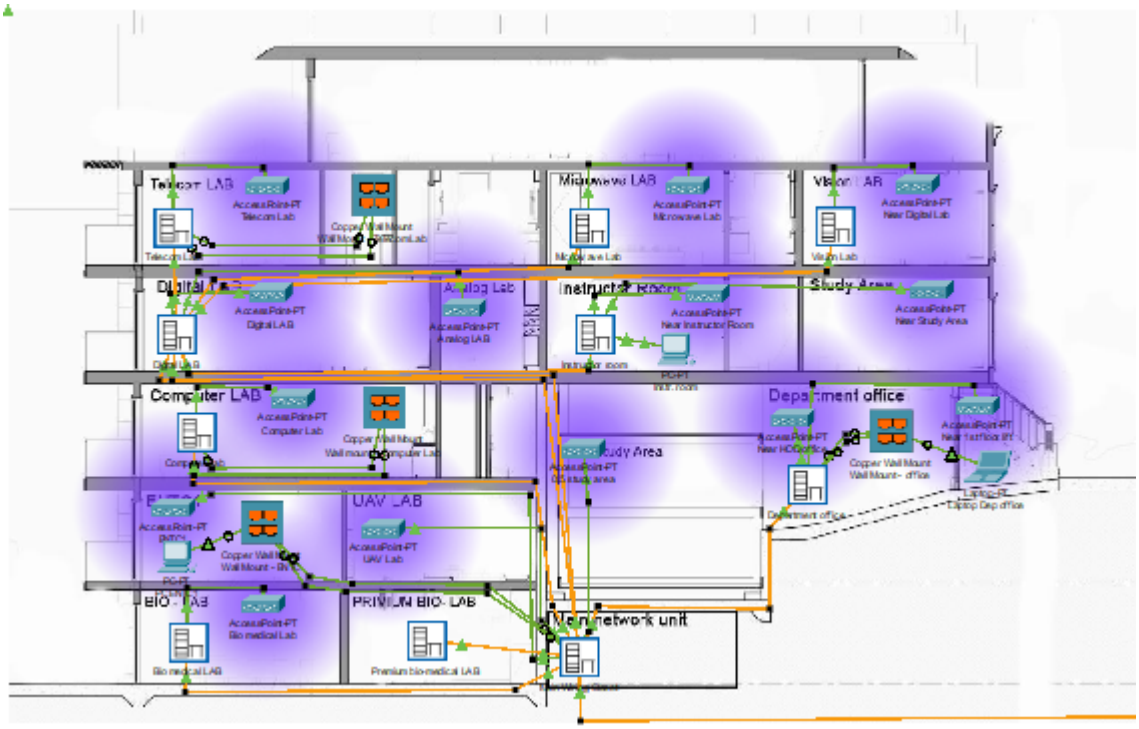


In the present network design of the UOM, there is one main router and eight switches. However, an extra switch has been added specifically for the library building due to a major connection problem.

This network design utilises a star topology, where all network connections are centralised at the router. This centralization greatly simplifies network management and monitoring, allowing administrators to easily identify and troubleshoot issues on individual connections or devices. The star topology is highly scalable, enabling the convenient addition of new devices to the network by connecting them to the router. This facilitates network expansion as the organisation grows, without disrupting the existing connections. Additionally, the star topology provides better performance compared to other topologies like bus or ring. Each device has its dedicated connection to the router, ensuring sufficient bandwidth and minimising network congestion. As a result, data transfer is faster, and the likelihood of collisions or data loss is reduced. Furthermore, the star topology enhances network security. With all connections centralised at the router, it becomes easier to implement security measures such as firewalls, intrusion detection systems, and access control mechanisms. This control over access to the central device helps safeguard the entire network from unauthorised access. And this topology is relatively simple to set up and manage. The connections between devices and the router are straightforward, reducing complexity and enabling administrators to easily comprehend and maintain the network.

This is the proposed network design for the Electronic and Telecommunication Department.





In the present network design of the department there is only one main three- layer switch which is directly connected to the backbone network of the university. And all the two layer switches in the department are connected to that three layer switch. In the proposed network design there are two, 2-layer switches which are directly connected to the 3 layer switch of the back bone network. The ground floor and the first floor devices will access to the network from one 2-layer switch and the 2nd layer, 3 rd layer devices will access to the network through the other two layer switch.

Active and Passive components in the Network

Active Components

Devices or equipment that actively contribute to the network by creating, changing, or forwarding network traffic are referred to as active network components. In order to operate and actively participate in the network's operation, these devices need power. Routers, switches, hubs, and access points are a few examples of active network components.

we have used the following switches, router and accesses points types in this newly designed network.

- 3650-24PS multilayer switches
- Cisco ASR 9010 router
- Cisco Catalyst 9166 Series Access Points
- Cisco Catalyst 2960 Layer 2 Switches

Specifications of Active Components

Cisco ASR 9010 router

The Cisco ASR 9010 router is a high-performance, modular edge router designed for service providers and large enterprises. It offers advanced routing, forwarding, and switching capabilities to handle high-volume traffic in demanding network environments. Here are some specifications of the Cisco ASR 9010 router:

1. Form Factor: The ASR 9010 router is a rack-mountable chassis-based system.

2. Performance: It delivers high-performance forwarding and routing with a capacity of up to 480 Gbps per slot.

3. Scalability: The router supports high-density Ethernet and IP/MPLS interfaces, providing scalability to accommodate growing network demands.

4. Interface Options: It supports a wide range of interface modules, including Ethernet, Gigabit Ethernet, 10 Gigabit Ethernet, and 100 Gigabit Ethernet. These modules offer various physical interfaces like RJ-45, SFP, SFP+, and QSFP+.

5. Modular Architecture: The ASR 9010 router follows a modular architecture, allowing for flexibility and easy expansion. It consists of multiple slots that can accommodate different types of line cards and service cards. In this ASR 9010 router has 8 line cards that can be connected fiber lines.

6. High Availability: The router provides high availability features such as redundant power supplies and fans, as well as support for hot-swappable modules for minimal downtime during maintenance or upgrades.

7. Network Protocols: It supports a wide range of network protocols, including IP, MPLS, BGP, OSPF, IS-IS, and many others, making it suitable for various network environments and deployments.

8. Control Plane and Management: The ASR 9010 router utilizes a distributed control plane architecture, which enhances scalability and resiliency. It also offers comprehensive management capabilities through Cisco IOS XR software, providing a rich set of features for configuration, monitoring, and troubleshooting.

9. Security Features: The router incorporates robust security features to protect network infrastructure and data, including Access Control Lists (ACLs), IPsec VPN, MPLS VPN, and Control Plane Policing (CoPP).

10. Carrier-Class Reliability: Designed for carrier-class deployments, the ASR 9010 router offers carrier-grade reliability, with features like Non-Stop Routing (NSR) and In-Service Software Upgrades (ISSU) to minimize service disruptions.

3650-24PS multilayer switches

The Cisco Catalyst 3650-24PS is a multilayer switch designed for enterprise network deployments. It combines wired and wireless capabilities, providing enhanced security, scalability, and intelligence for network operations. Here are the specifications of the Cisco Catalyst 3650-24PS multilayer switch:

1. Form Factor: The Catalyst 3650-24PS switch has a compact 1U rack-mountable form factor.

2. Port Density: It offers 24 Ethernet ports for connecting devices to the network. These ports support various speeds, including 10/100/1000 Mbps (Gigabit Ethernet).

3. Power over Ethernet (PoE): The switch provides Power over Ethernet (PoE) capabilities on all 24 ports, enabling it to power compatible devices such as IP phones, wireless access points, and surveillance cameras.

4. Uplink Ports: In addition to the 24 Ethernet ports, the switch has four SFP (Small Form-Factor Pluggable) uplink ports. These ports can support various types of optical or copper uplink connections, including Gigabit Ethernet and 10 Gigabit Ethernet.

5. Switching Capacity: The Catalyst 3650-24PS switch has a switching capacity of up to 88 Gbps, allowing for high-speed data forwarding and inter-VLAN routing.

6. Performance and Scalability: It supports up to 1,000 VLANs and can handle up to 1,000 active VLANs simultaneously. The switch also supports up to 4,000 VLAN IDs.

7. Multilayer Features: The switch provides Layer 2 and Layer 3 functionality, allowing for advanced features such as VLANs, Spanning Tree Protocol (STP), Rapid Spanning Tree Protocol (RSTP), and Virtual Router Redundancy Protocol (VRRP) for high availability.

8. Wireless LAN Controller (WLC) Integration: The Catalyst 3650-24PS switch can function as a wireless LAN controller, enabling centralized management and control of Cisco wireless access points (APs) and client devices.

9. Security Features: It incorporates advanced security features, including Access Control Lists (ACLs), Secure Shell (SSH) for secure remote management, and support for Network Admission Control (NAC) for enforcing network security policies.

10. Network Management: The switch can be managed using Cisco IOS Software, which provides a familiar command-line interface (CLI) for configuration and monitoring. It also supports Cisco Prime Infrastructure for centralized network management.

11. Energy Efficiency: The Catalyst 3650-24PS switch is designed to be energy-efficient, with features like Energy Efficient Ethernet (EEE) and Cisco Energy Wise technology, which helps optimize power consumption and reduce operational costs.

Cisco Catalyst 9166 Series Access Points

The Cisco Catalyst 9166 Series Access Points offer high-performance wireless connectivity and a range of features. We used those because those have following specifications

1. Part Numbers and Regulatory Domains: The Catalyst 9166 Series is available in different regulatory domains. Customers need to verify approval for use in their countries.

2. Software: It runs on Cisco IOS XE Software Release 17.9.1 or later.

3. Supported Wireless LAN Controllers: Compatible with Cisco Catalyst 9800 Series Wireless Controllers (physical or virtual).

4. Wireless Standards: Supports 802.11n, 802.11ac, and 802.11ax with various capabilities.

5. Integrated Antenna: Internal omnidirectional antennas with different gains for frequency bands.

6. Interfaces: Features Multigigabit Ethernet, management console port, and USB 2.0.

7. Indicators: Status LEDs provide information on various statuses and errors.

8. Dimensions and Weight: Compact dimensions without mounting brackets, weighing approximately 3.54 lb. (1.60 kg).

9. Power Requirements: Supports various Power over Ethernet options and DC power input.

10. Environmental Specifications: Operating temperature of 32° to 122°F (0° to 50°C) and humidity of 10% to 90% (non-condensing).

11. System Memory: Equipped with 2048 MB DRAM and 1024 MB flash memory.

12. Warranty: Comes with a limited lifetime hardware warranty.

13. Regulatory Compliance: Meets safety, emissions, immunity, and radio compliance standards. Certified by Wi-Fi Alliance and Bluetooth SIG.

Cisco Catalyst 2960 Layer 2 Switches

1. Models

Cisco Catalyst 2960L-8TS-LL: 8 Ethernet 10/100/1000 ports with 2 SFP ports

2. Performance:

Forwarding Bandwidth: Up to 70 Gbps

Switching Capacity: Up to 140 Gbps

Forwarding Rate: Up to 104.16 Mpps

3. Layer 2 Features:

VLAN Support: IEEE 802.1Q VLANs

Spanning Tree Protocol (STP) Support:

IEEE 802.1D Spanning Tree Protocol

IEEE 802.1w Rapid Spanning Tree Protocol

IEEE 802.1s Multiple Spanning Tree Protocol

Link Aggregation Control Protocol (LACP): IEEE 802.3ad

VLAN Trunking Protocol (VTP): VTP v1, v2, v3

Port Security: MAC-based and IEEE 802.1X-based

Quality of Service (QoS): Support for IEEE 802.1p, DiffServ, and DSCP

4. PoE Support:

Some models support PoE (Power over Ethernet) or PoE+ to provide power to connected devices, such as IP phones, wireless access points, and IP cameras.

5. Management:

Cisco IOS Software: Support for Cisco IOS Software with a range of Layer 2 features and management capabilities.

Management Interfaces: Support for console port and Ethernet management port.

Remote Management Protocols: SNMPv1, SNMPv2c, SNMPv3, Telnet, SSH, and HTTP.

6. Security:

Network Security: Support for features such as MAC address filtering, DHCP snooping, Dynamic ARP Inspection (DAI), and IP source guard.

Access Control Lists (ACLs): Support for ACL-based security filtering.

Passive components

Passive network components do not actively alter network traffic or take part in network functioning. Typically powerless, these parts are frequently utilized for physical connectivity or monitoring. Patch cables, wall plates, jacks, and network taps are a few examples of passive network components.

we have used the following passive components in this newly designed network.

- Ethernet cables
- Fiber optic cables
- Connectors
- patch panels.

Specifications of passive components

1. Cat5e Ethernet Cable:

- Max Data Rate: 1000 Mbps
- Bandwidth: Up to 100 MHz
- Cable Length: Up to 100 meters
- Connector: RJ-45

2. Cat6 Ethernet Cable:

- Max Data Rate: 10 Gbps
- Bandwidth: Up to 250 MHz
- Cable Length: Up to 55 meters
- Connector: RJ-45

3.Fiber Optic Cables:

1. Single-Mode Fiber Optic Cable:

- Core Size: 9/125 microns
- Max Data Rate: Up to 100 Gbps
- Max Distance: Up to 10 kilometers
- Connectors: SC, LC, or FC

2. Multimode Fiber Optic Cable:

- Core Size: 50/125 or 62.5/125 microns
- Max Data Rate: Up to 40 Gbps (OM3) or 100 Gbps (OM4)
- Max Distance: Up to 550 meters (OM3) or 400 meters (OM4)
- Connectors: SC, LC, or ST

4.Connectors:

1. RJ-45 Connector:

- Used for Ethernet cables
- Eight-pin connector
- Suitable for twisted-pair copper cables

2. SC Connector:

- Used for fiber optic cables.
- Push-pull design
- Suitable for single-mode and multimode cables

3. LC Connector:

- · Used for fiber optic cables.
- · Small form factor connector
- · Suitable for single-mode and multimode cables

Patch Panels:

1. 24-Port Cat6 Patch Panel:

- · 24 RJ-45 ports
- · Suitable for Cat6 Ethernet cables
- · 1U rack-mountable design

2. 48-Port Fiber Optic Patch Panel:

- · 48 SC or LC ports
- · Suitable for single-mode or multimode fiber optic cables
- · 1U or 2U rack-mountable design

IP Addressing

For the ip addressing , we used ip version 4 . Total ip address allocation among departments and buildings is mentioned in the table below.

Section	**No. of staff member**s	**No.of allocated IP addressess**	**Ip address subnet allocation**
Library	1000	2^10 = 1024	/22
Mechanical	600	2^10 = 1024	/22
Sumandasa building	1000	2^10 = 1024	/22

Civil	600	2^10 = 1024	/22
ADMIN	400	2^9 = 512	/23
ER	300	2^9 = 512	/23
Textile	600	2^10 = 1024	/22
IT	800	2^10 = 1024	/22
ENTC	800	2^10 = 1024	/22
Total required No .of IP addresses = 8192			

So we decided to take /19 IP address network from the ISP. Then divided that /19 network into eight /22 subnets. One of /22 subnet is again divided into two /23 subnets which are for the ADMIN and ER nodes.

We took the network ID provided to the university by the ISP is 10.10.32.0 . We used a router which has 8 gigabiteEthernet fiber ports, so we created eight /22 subnets. IP address allocation for each interface of the router is show below.

Library interface	10.10.32.1
Mechanical	10.10.36.1
Sumanadasa building	10.10.40.1
Civil	10.10.44.1
ENTC	10.10.48.1
ADMIN/ER	10.10.52.1
Textile	10.10.56.1
IT	10.10.60.1

At each node (Layer 3 switch) we have added DHCP servers to assign IP addresses in the respective subnet automatically.

Bill of quantities (Backbone & ENTC)

For Backbone Network

Component	Quantity	Unit Price(USD)	Cost(USD)
Fiber single mode cable	1300m	9.1	11830.00
Fiber multi mode cable	300m	12.78	3834.00
Router	1	19995	19995.00
Layer 3 Switch	10	3400	34000.00
Fairwall	2	2400	4800.00

For ENTC Network

Component	Quantity	Unit Price(USD)	Cost(USD)
Fiber cable multi mode	310m	12.78	3961.8
Copper cables	360m	8.5	3060.00
Patch Panel	12	50	600.00
Layer 3 Switch	1	3300	3300.00
Layer 2 Switch	10	1774	17740.00

Simulation results

In Cisco Packet Tracer, various types of packets are used to simulate network communication and behavior. Here are some common packet types that Cisco Packet Tracer encounters:

1. Ethernet Frames: Ethernet frames are used to encapsulate data at the data link layer (Layer 2) of the OSI model. They contain the source and destination MAC addresses, type/length information, and the actual data payload.

2. IP Packets: IP (Internet Protocol) packets are used to encapsulate data at the network layer (Layer 3) of the OSI model. They include the source and destination IP addresses, as well as the data payload.

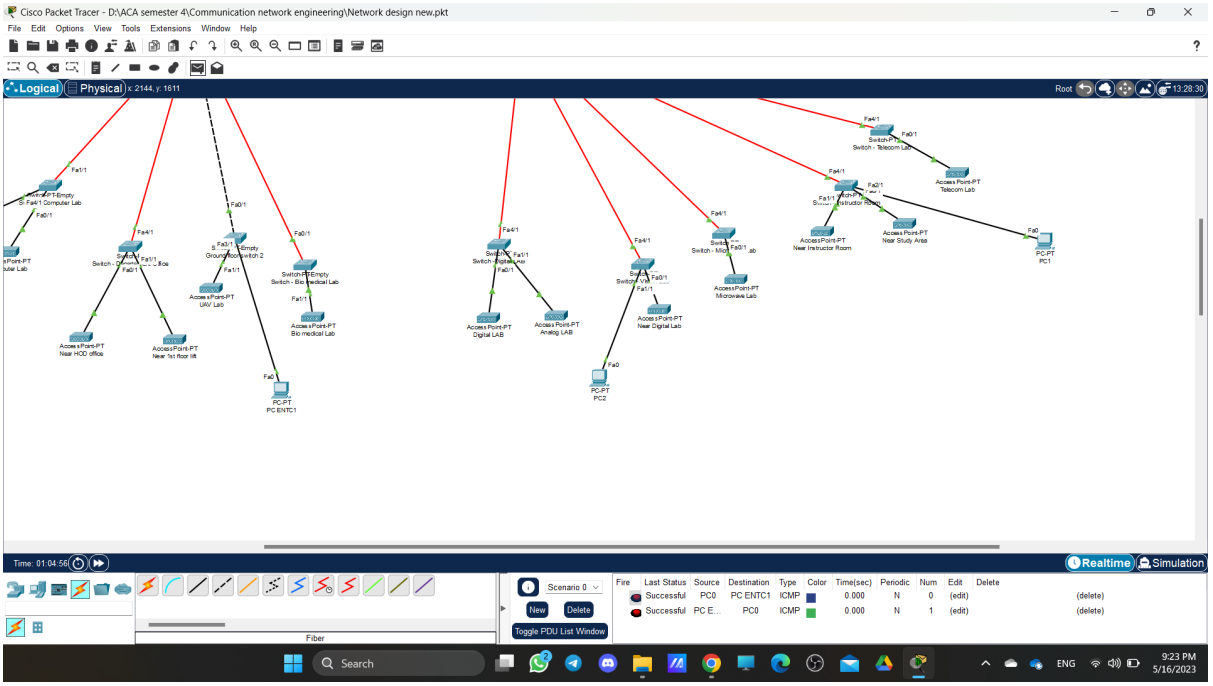
3. ICMP Packets: ICMP (Internet Control Message Protocol) packets are used for network diagnostic and error reporting. They include various types of messages, such as echo request (ping) and echo reply, which are commonly used for network troubleshooting.

4. TCP Segments: TCP (Transmission Control Protocol) segments are used for reliable, connection-oriented data transmission. They contain source and destination port numbers, sequence numbers, acknowledgments, and other control information.

5. UDP Datagrams: UDP (User Datagram Protocol) datagrams are used for connectionless, unreliable data transmission. They contain source and destination port numbers, as well as the data payload.

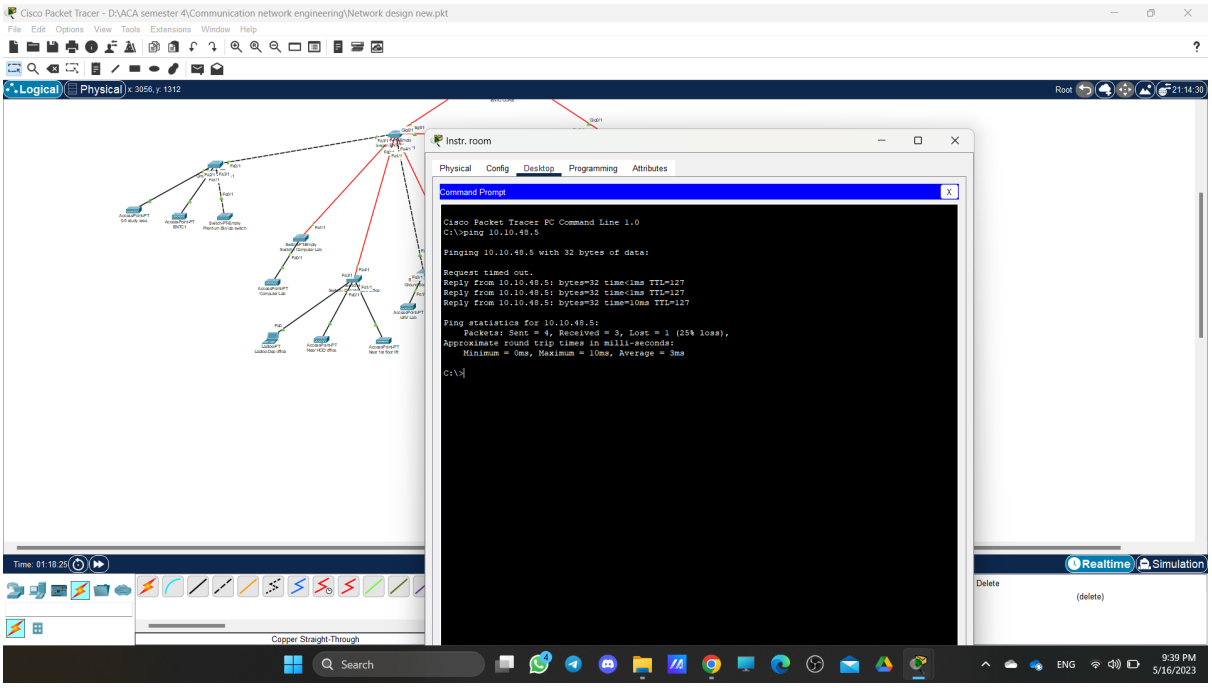
6. ARP Requests/Replies: ARP (Address Resolution Protocol) is used to map IP addresses to MAC addresses on the local network. ARP requests and replies are used to resolve the MAC address of a device given its IP address.

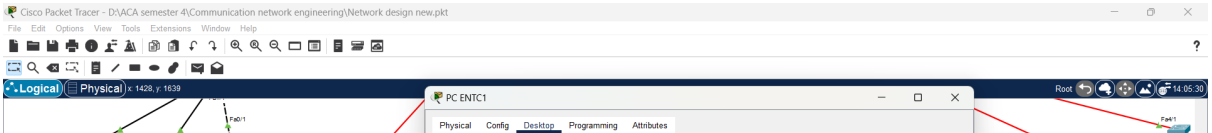
We have studied the local area network of ENTC. Then we designed a new local area network for ENTC and simulated it using Cisco Packet Tracer. The newly designed network and simulation results are shown below.

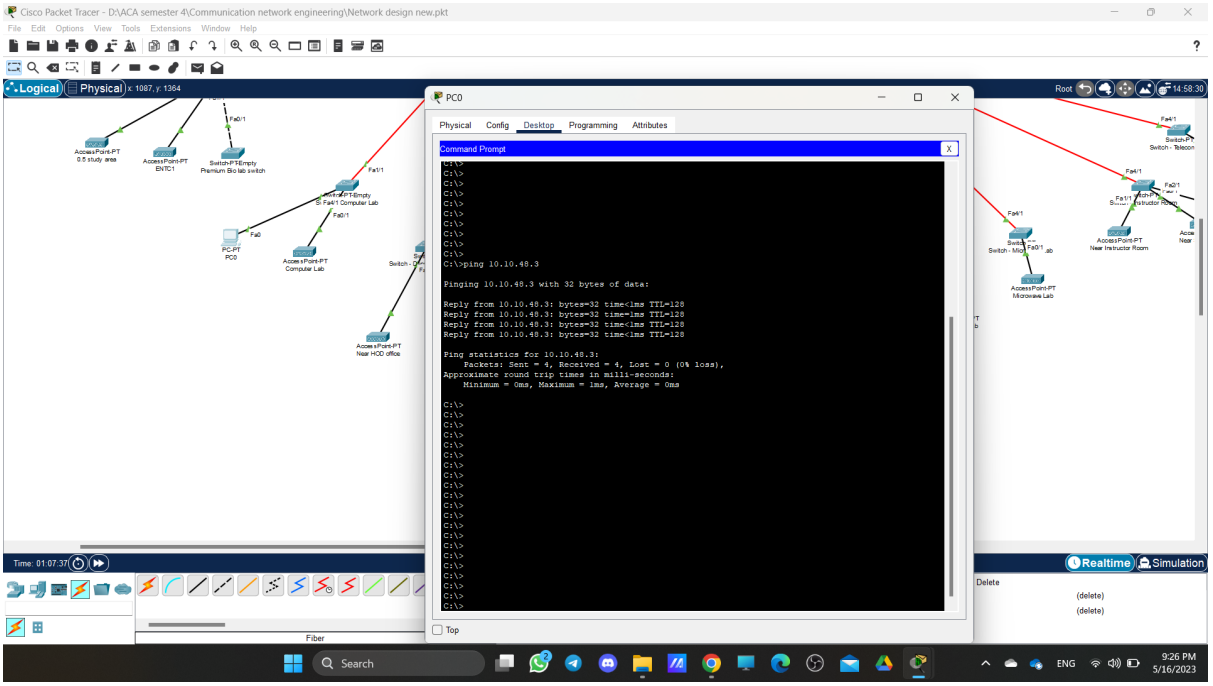


Successful UDP packet transfer between two computers

Pinging between different computers in the network






Cisco Packet Tracer - D:\ACA semester 4\Communication network engineering\Network design new.pkt
File Edit Options View Tools Extensions Window Help
Logical
Physical
PC0
Physical Config Desktop Programming Attributes
Command Prompt
C:\>ping 10.10.48.3
Pinging 10.10.48.3 with 32 bytes of data:
Reply from 10.10.48.3: bytes=32 time<1ms TTL=128
Reply from 10.10.48.3: bytes=32 time=1ms TTL=128
Reply from 10.10.48.3: bytes=32 time<1ms TTL=128
Reply from 10.10.48.3: bytes=32 time<1ms TTL=128
Ping statistics for 10.10.48.3:
Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 1ms, Average = 0ms
Top
Realtime
Simulation
Fiber
Delete
(delete)
(delete)
Search
ENG
9:26 PM
5/16/2023