Department of Electronic & Telecommunication Engineering, University of Moratuwa, Sri Lanka.

Design of Local Area Network

220017F Ahilakumaran T.
220321G Kishopan L.
220327F Kopithan M.
220400A Mugesram K

Submitted in fulfillment of the requirements for the module
EN2150 - Communication Network Engineering

Date 23.04.2025

Contents

1 Introduction

This proposal explains the plan to create a strong and reliable backbone network for the University of Moratuwa. The backbone network will serve as the main communication link between different floors and buildings on the university campus. It will ensure that data is transferred quickly, smoothly, and without interruptions. To achieve this, the design includes the use of fiber-optic cables, which are ideal for fast and long-distance connections. High-performance network switches will be used to handle large amounts of data traffic efficiently. Additionally, modern routing and switching techniques will be applied to improve the overall speed, stability, and performance of the network.

2 Internal Network of the ENTC Building

2.1 Features of the Local Area Network of the ENTC

- The Department of Electronic and Telecommunication Engineering (ENTC) uses a flat Local Area Network (LAN) architecture.
- The ENTC LAN is connected to the University of Moratuwa's backbone network through a Layer 3 switch known as the ENTC node.
- The ENTC node switch supports a maximum data rate of **10 Gbps**.
- A Layer 3 core switch in the ENTC LAN is connected to the ENTC node switch via a **10 Gbps fiber link**.
- Eight 24-port Layer 2 network switches are connected to the ENTC core switch via **1 Gbps fiber links**. These switches are located in:
  - Biomedical Engineering Laboratory
  - Computer Laboratory
  - Department Office
  - Digital Electronic Laboratory
  - Instructors' Room
  - Telecommunication Laboratory
  - Microwave Laboratory
  - Vision Laboratory
- Additional 24-port network switches are connected to the ENTC core switch using **copper UTP cables**, including:
  - One switch inside the Premium Biomedical Engineering Laboratory
  - Two switches inside the Network Room (Ground Floor)
- The building contains **14 wireless access points (WAPs)** connected to the LAN.

2.2 The Internal Network of One Building (ENTC)

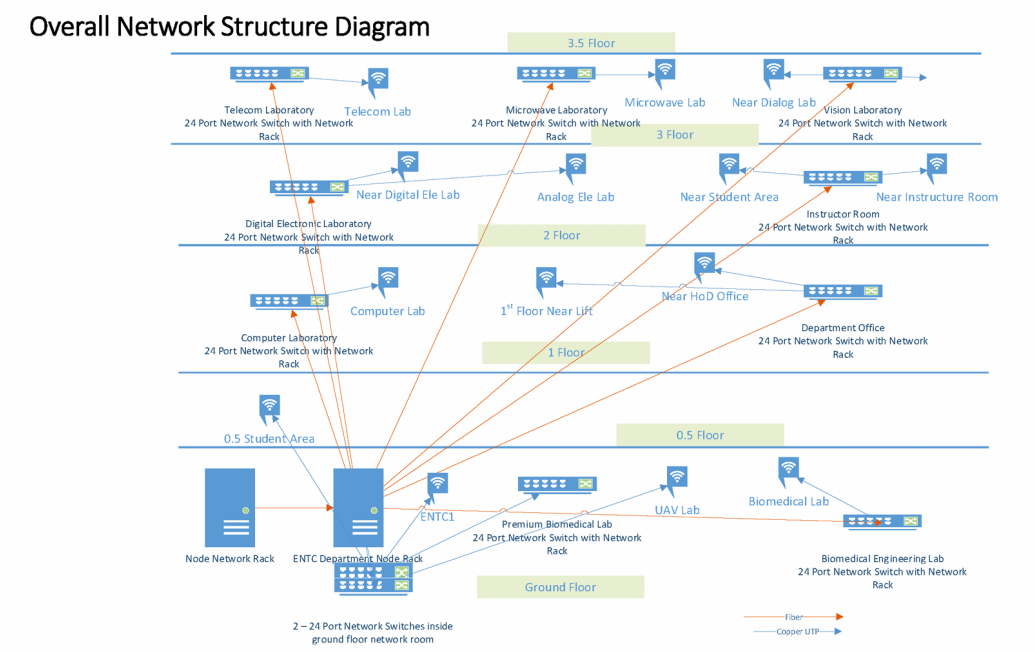

Figure 1: ENTC Department Network Topology

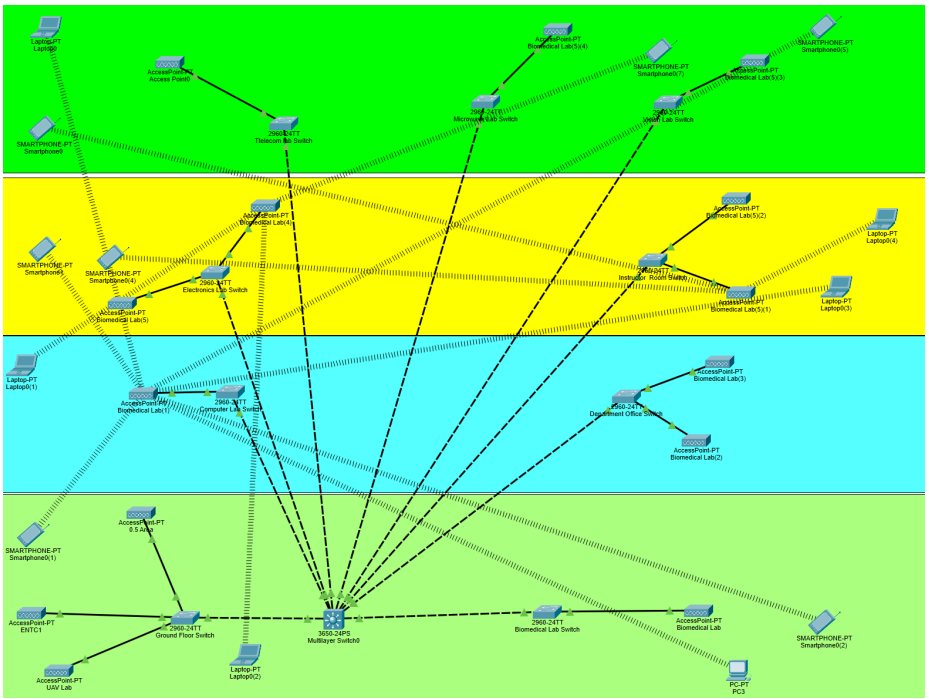

Figure 2: ENTC Department Network Topology (Cisco Logical View)

2.3 ENTC LAN Simulation

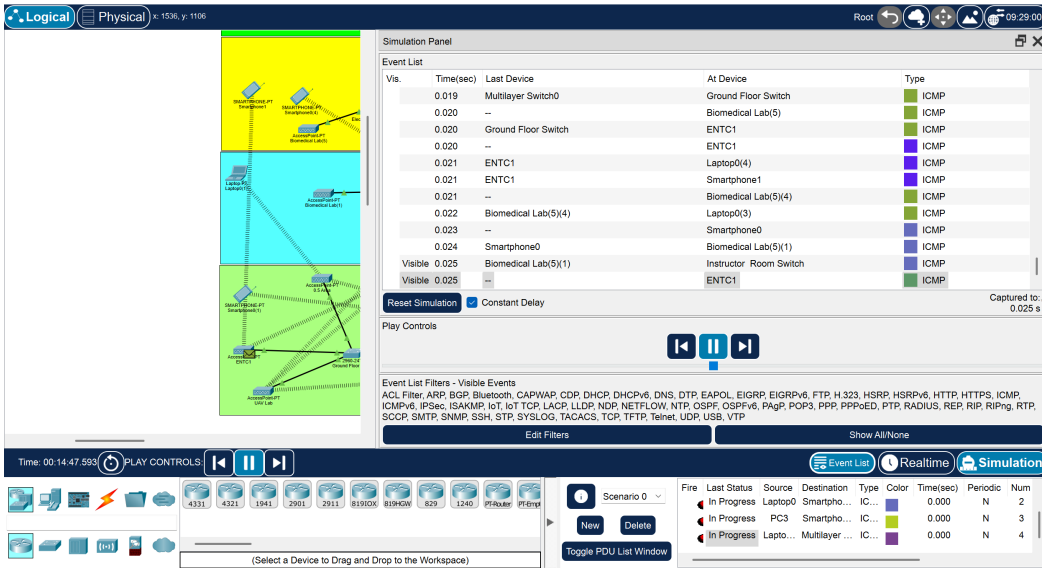

Figure 3: Simulation of ENTC LAN

2.4 Ensuring Secure Wireless Access

To maintain secure wireless access across high-level administrative offices throughout the University of Moratuwa—such as the Chancellor's and Vice-Chancellor's offices—the university has implemented several important security measures:

- **VLAN Segmentation:** A dedicated VLAN is configured for wireless communication within administrative areas. This isolates the access points and connected workstations from the general university network, reducing unnecessary broadcast traffic and protecting sensitive data.
- **WPA2-Enterprise Authentication:** Wireless access in administrative offices uses the WPA2-Enterprise protocol, which requires users to authenticate with unique credentials. These credentials are assigned only to authorized personnel and verified using a central RADIUS (Remote Authentication Dial-In User Service) server, ensuring strong access control.
- **Controlled Wireless Coverage:** To further improve security, wireless signal coverage is physically restricted using specialized antennas. These antennas limit signal range to only the specific administrative office areas, minimizing the risk of unauthorized external access.

By applying these measures consistently across the university, the University of Moratuwa ensures that wireless connectivity in administrative areas is secure, reliable, and accessible only to authorized personnel.

3 The Backbone Network for University of Moratuwa

3.1 University Backbone Network

Hierarchical Network Architecture

The backbone network at the University of Moratuwa will adopt a hierarchical design, composed of three primary layers: Core, Distribution, and Access. This structure enables modularity, scalability, and easier fault isolation. The core layer interconnects all major buildings and provides high-speed routing between them. The distribution layer aggregates connections from different floors within buildings, while the access layer connects end-user devices such as computers and printers.

High-Speed Switching and Cabling

To support high data throughput, high-performance Layer 3 core switches will be deployed, capable of running dynamic routing protocols like OSPF and EIGRP. Distribution and access switches will support VLANs and Power over Ethernet (PoE) where necessary. Fiber-optic cables will be used for long-distance connections between buildings and floors, ensuring fast and interference-free data transmission. For shorter runs at the access level, high-quality copper cables (such as UTP) will be used.

Resilience and Redundancy

To improve network reliability and minimize downtime, redundancy will be implemented at both the link and power levels. Link Aggregation Control Protocol (LACP) will be used to bundle multiple links, ensuring failover capability. In addition, critical switches will be equipped with dual power supplies and connected to backup power systems to maintain connectivity during outages.

Security and Traffic Segmentation

The network will be protected using several layered security mechanisms. Access Control Lists (ACLs) will be applied to manage traffic permissions, while firewalls and Intrusion Detection and Prevention Systems (IDS/IPS) will monitor for suspicious activity. VLAN segmentation will isolate sensitive areas such as administrative networks and labs, reducing exposure to unauthorized access and broadcast storms.

Centralized Monitoring and Management

To maintain optimal network health, centralized monitoring tools will be used for real-time performance tracking, fault detection, and configuration management. Simple Network Management Protocol (SNMP) will be implemented to allow IT staff to manage devices remotely and respond quickly to issues across the campus-wide network infrastructure.

3.2 University of Moratuwa Core Network Architecture

The core network at the University of Moratuwa uses a ring topology to ensure reliable and continuous connectivity. This design allows communication to continue even if one connection fails. The network backbone links two main server locations: the Sumanadasa Building and the Center for Information Technology Services (CITeS), which act as the central hubs for data and services.

There are nine main access nodes across the campus to provide wide coverage and easy access. These nodes are located at: the Network Operating Center at CITeS, the Faculty of IT, the Department of Electronic and Telecommunication Engineering, the Sumanadasa Building, the Civil Engineering Department, the Transport and Logistics Department, the Materials Engineering Department, the Mechanical Engineering Department, and the Administration Building. This structure enables smooth and efficient communication across departments and administrative units.

3.3 Backbone Network Design Considerations and Assumptions

This section outlines the key assumptions and design considerations in planning the backbone network for the University of Moratuwa. The aim is to build a scalable, high-performance network using Layer 3 switches as core nodes in key departments and administrative buildings, all connected to a central Network Operations Center (NOC) with secure internet access and integrated server infrastructure.

3.3.1 Assumptions in Network Design

The design assumes a high volume of data transfer between the main campus and its branch locations. To accommodate this:

- **High-bandwidth leased lines** are proposed for connections between the main campus and branch offices to support symmetrical, reliable, and dedicated data links.
- **Cost-effective leased lines** are used for nearby branch offices due to reduced installation and maintenance costs.
- **Frame Relay with PVC and CIR** is used between branch offices with lower data transfer needs. This ensures reliable performance with guaranteed minimum bandwidth.
- **Layer 3 switches** serve as core nodes in major buildings to enable efficient routing and segmentation.
- **A centralized NOC** provides administrative control and centralized monitoring of network health and security.

3.3.2 Design Components and Infrastructure

The backbone network includes structured components to ensure stability, security, and performance:

- **Entrance Facility:** Interfaces the university network with the ISP via routers and switches.
- **Equipment Room:** Houses networking gear including core switches, routers, firewalls, and servers in a secure and climate-controlled environment.
- **Fiber-optic Backbone:** Connects different floors and buildings using high-speed fiber links, ensuring low latency and high reliability.
- **Horizontal Cabling:** Utilizes copper UTP cables for intra-floor connections, linking end-user devices to access switches.
- **Work Areas:** End-user locations with wired or wireless access to the network.
- **Telecommunication Enclosures:** Contain switches and patch panels for easy access and flexibility in managing floor-level connectivity.
- **Redundancy and Security:** Dual core switches and routers offer failover capability. Firewalls and a DMZ safeguard services like web hosting. Gateway routers securely connect to external networks.
- **Server Infrastructure:** Includes essential services like DNS, DHCP, Mail, FTP, AD/RADIUS, all with static IPs for reliability. Servers connect to a central switch linked to the core network.

This design ensures the backbone network is secure, maintainable, and scalable, with provisions for redundancy and centralized monitoring.

3.4 Network Diagram of BackBone

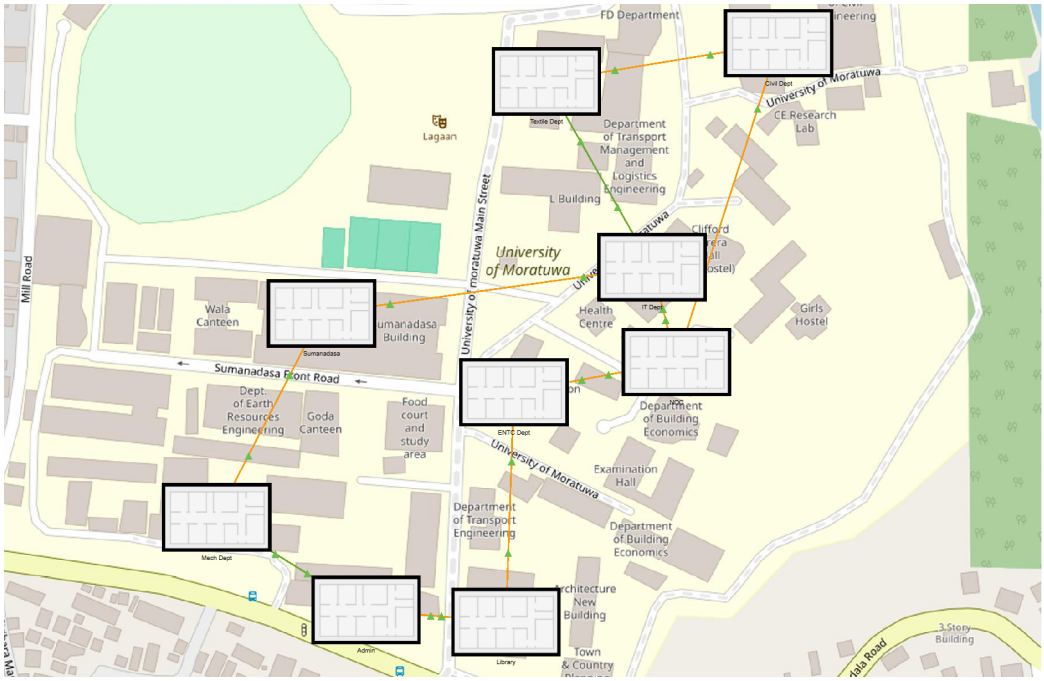

Figure 4: UOM BackBone Network(Cisco Physical View)

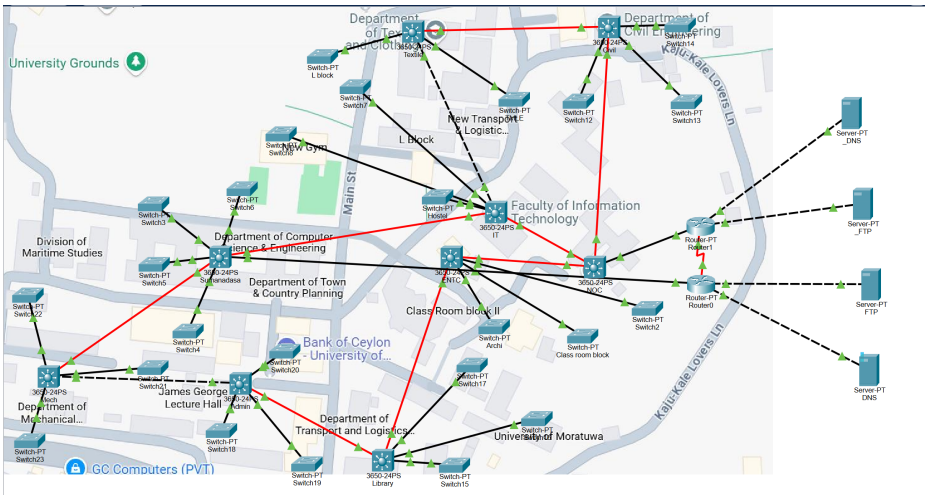

Figure 5: UOM BackBone Network (Cisco Logical View)

3.5 Simulation of BackBone Network

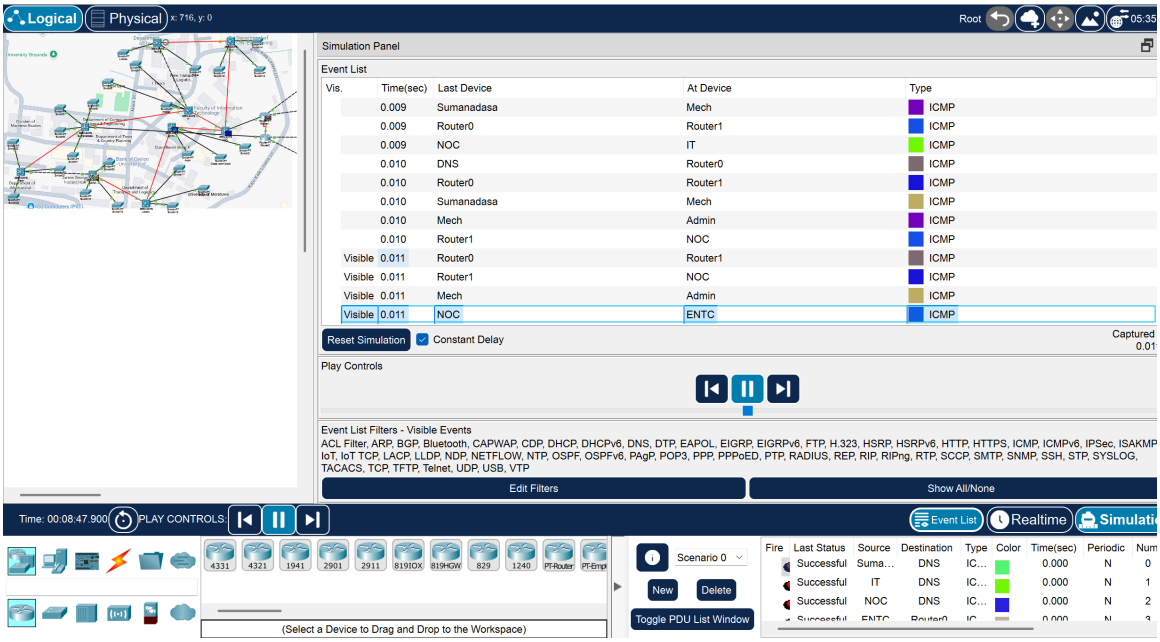

Figure 6: Simulation of BackBone Network

3.5.1 OSPF in Ring Topology

The OSPF (Open Shortest Path First) routing protocol is highly compatible with ring topology due to its ability to dynamically calculate the shortest and most efficient paths for data packets. The circular design of a ring topology ensures multiple redundant paths, enabling OSPF to reroute traffic seamlessly in case of link or node failures. This minimizes downtime and ensures consistent network performance. Additionally, OSPF's ability to quickly converge and adapt to changes makes it ideal for maintaining high availability and reliability in networks employing a ring structure.

3.6 IPV4 Addressing Scheme

Switch Configuration: Sumanadasa Building

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	10.0.112.1	255.255.252.0
GigabitEthernet1/0/2	10.0.116.1	255.255.252.0
GigabitEthernet1/0/3	10.0.120.1	255.255.252.0
GigabitEthernet1/0/4	10.0.124.1	255.255.252.0
GigabitEthernet1/0/5	10.10.130.2	255.255.255.0
GigabitEthernet1/1/1	192.168.50.1	255.255.255.0
GigabitEthernet1/1/3	192.168.60.2	255.255.255.0

Table 1: Link Information with Subnet Masks for Hostname: Sumanadasa

Switch Configuration: Mechanical Engineering Department

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	192.168.40.1	255.255.255.0
GigabitEthernet1/0/2	10.0.96.1	255.255.252.0
GigabitEthernet1/0/3	10.0.100.1	255.255.252.0
GigabitEthernet1/0/4	10.0.104.1	255.255.252.0
GigabitEthernet1/1/1	192.168.50.2	255.255.255.0

Table 2: Link Information with Subnet Masks for Hostname: Mech

Switch Configuration:Administration Building

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	192.168.40.2	255.255.255.0
GigabitEthernet1/0/2	10.0.80.1	255.255.252.0
GigabitEthernet1/0/3	10.0.84.1	255.255.252.0
GigabitEthernet1/0/4	10.0.88.1	255.255.252.0
GigabitEthernet1/1/1	192.168.30.2	255.255.255.0

Table 3: Link Information with Subnet Masks for Hostname: Admin

Switch Configuration: Library

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	10.0.64.1	255.255.252.0
GigabitEthernet1/0/2	10.0.68.1	255.255.252.0
GigabitEthernet1/0/3	10.0.72.1	255.255.252.0
GigabitEthernet1/1/1	192.168.30.1	255.255.255.0
GigabitEthernet1/1/2	192.168.20.2	255.255.255.0

Table 4: Link Information with Subnet Masks for Hostname: Library

Switch Configuration: ENTC

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	10.0.16.1	255.255.252.0
GigabitEthernet1/0/2	10.0.20.1	255.255.252.0
GigabitEthernet1/0/3	10.0.24.1	255.255.252.0
GigabitEthernet1/1/1	192.168.10.2	255.255.255.0
GigabitEthernet1/1/2	192.168.20.1	255.255.255.0

Table 5: Link Information with Subnet Masks for Hostname: ENTC

Switch Configuration: NOC

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	10.100.0.2	255.255.255.0
GigabitEthernet1/1/1	192.168.10.1	255.255.255.0
GigabitEthernet1/1/2	192.168.100.1	255.255.255.0
GigabitEthernet1/1/3	192.168.80.1	255.255.255.0

Table 6: Link Information with Subnet Masks for Hostname: NOC

Switch Configuration: Civil Engineering Department

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	10.0.48.1	255.255.252.0
GigabitEthernet1/0/2	10.0.52.1	255.255.252.0
GigabitEthernet1/0/3	10.0.56.1	255.255.252.0
GigabitEthernet1/1/1	192.168.90.1	255.255.255.0
GigabitEthernet1/1/2	192.168.80.2	255.255.255.0

Table 7: Link Information with Subnet Masks for Hostname: Civil

Switch Configuration: Textile Engineering Department

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	192.168.70.1	255.255.255.0
GigabitEthernet1/0/2	10.0.128.1	255.255.252.0
GigabitEthernet1/0/3	10.0.132.1	255.255.252.0
GigabitEthernet1/0/4	10.0.136.1	255.255.252.0
GigabitEthernet1/1/1	192.168.90.2	255.255.255.0

Table 8: Link Information with Subnet Masks for Hostname: Textile

Switch Configuration: IT

Port	IP Address	Subnet Mask
GigabitEthernet1/0/1	192.168.70.2	255.255.255.0
GigabitEthernet1/0/2	10.0.32.1	255.255.252.0
GigabitEthernet1/0/3	10.0.36.1	255.255.252.0
GigabitEthernet1/0/4	10.0.40.1	255.255.252.0
GigabitEthernet1/1/1	192.168.100.2	255.255.255.0
GigabitEthernet1/1/2	192.168.60.1	255.255.255.0

Table 9: Link Information with Subnet Masks for Hostname: IT

3.7 Justification for Backbone

For the University of Moratuwa's backbone network, active routers are the preferred choice due to their advanced features, scalability, and ability to handle complex routing demands. With a large-scale infrastructure and numerous users, active routers offer dynamic routing protocols, advanced routing functionalities, Quality of Service (QoS) capabilities, and robust security features. These routers provide the necessary intelligence, flexibility, and scalability to support the university's expanding network requirements and ensure reliable connectivity for departments, research facilities, and campus-wide services.

Selection of Fiber Optic Cables

When selecting between single-mode and multi-mode fiber optic cables for active and passive components, several factors need to be considered:

Single-Mode Fiber Optic Cables

Single-mode fiber optic cables are designed to transmit data over longer distances compared to multi-mode cables. They have a smaller core size and allow for a single pathway for light transmission. Single-mode fiber is ideal for backbone networks requiring long-distance connectivity, such as interconnecting routers in different buildings or across large campuses. It offers:

- Higher bandwidth
- Lower signal loss over long distances
- Reliable and high-performance communication

Multi-Mode Fiber Optic Cables

Multi-mode fiber optic cables have a larger core size, allowing multiple pathways for light transmission. This makes them suitable for shorter-distance communication within buildings or floors. Multi-mode fiber is commonly used for connecting devices within the same location, such as switches within a data center or routers within a building. It offers:

- Cost-effective connectivity for shorter distances
- Moderate to high bandwidth support

Implementation Details

- Connections between the **Admin and Mech departments** and the **IT and Textile departments** use **multi-mode fiber optic cables** due to the relatively short distances between these nodes.
- All other backbone connections between Layer 3 switch nodes use **single-mode fiber optic cables** to ensure high performance over long distances across the campus.

- Connections from the switches to end devices use **copper cables**, which are cost-effective and suitable for shorter distances within a building.

3.8 Specifications of Layer 3 Switches

The Cisco Catalyst 3650-24PS Layer 3 switch provides the following specifications, making it an ideal choice for the university's backbone network:

- **24 Gigabit Ethernet Ports:** High-speed connections for devices and uplinks.
- **Dynamic Routing Support:** Includes protocols such as OSPF, EIGRP, and BGP for efficient route management.
- **Integrated Power over Ethernet (PoE):** Supports devices like IP phones and access points without additional power adapters.
- **StackWise Technology:** Enables multiple switches to function as a single logical unit, enhancing scalability.
- **Advanced Security Features:** Includes access control lists (ACLs) and Secure Socket Layer (SSL) for secure communications.
- **QoS Capabilities:** Ensures optimized performance for critical applications.
- **Energy Efficiency:** Compliant with modern energy-saving standards.

3.8.1 Why Layer 3 Switches are Preferred Over Routers for Backbone Networks

Layer 3 switches are typically favored over routers for backbone networks for several reasons:

- **Faster Performance:** Layer 3 switches provide faster packet forwarding due to their hardware-based switching, whereas routers perform routing using software, making them slower in high-throughput environments.
- **Cost-Effective:** Layer 3 switches are generally more cost-effective compared to routers in scenarios where routing between VLANs (Virtual Local Area Networks) or IP subnets is required. They combine the functionality of both switches and routers, thus reducing hardware costs.
- **Higher Scalability:** With technologies like StackWise, Layer 3 switches allow for easy scalability by stacking multiple switches to act as a single unit, making them more adaptable for growing networks.
- **Reduced Complexity:** By integrating routing capabilities directly into switches, Layer 3 switches simplify network design and management, avoiding the need for separate routers and switches.
- **Optimized for High-Speed Traffic:** Layer 3 switches are designed to handle large amounts of data with minimal latency, making them ideal for backbone networks where high-speed data transfer is essential.

These features provide robust performance, ease of management, and future-proofing for the university's growing network demands.

4 Bill of Materials

Device Type	Model	Quantity	Unit Price ($)	Total Price ($)
Layer 3 Switch	WS-C3650-24PS-L	9	3,059	27,531
Layer 2 Switch	WS-C2960-24TT-L	25	221	5,525
Server	APIC-SERVER-M1_RF	4	8,666	34,664
Router	10000-SIP-600	2	15,000	30,000
			Grand Total	**97,720**